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NAVWEPS REPORT

WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF
ATTACK UP TO 70 DEGREES (U)

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4 OCTOBER 1960

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TECH. DIVISION
U.S. NAVY



U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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Aerodynamics Research Report 125

WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT
ANGLES OF ATTACK UP TO 70 DEGREES

Prepared by

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F. J. LeMeritte

ABSTRACT: This report presents the results of an investigation in the NOL Supersonic Tunnel No. 1 to measure the static stability and drag of the Navy low-drag bomb at angles of attack up to 70 degrees. These data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

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U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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The purpose of this investigation was to obtain stability and drag data at high angles of attack on the Navy low-drag bomb for trajectory calculations. The wind-tunnel test was performed at the request of the Naval Weapons Laboratory (reference (a)), under Task Number 526. Other reports on the low-drag bomb shape are given in references (b) through (m).

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Captain, USN
Commander

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By direction

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NAVWEPS REPORT 7291

CONTENTS

	Page
INTRODUCTION.....	1
AERODYNAMIC SYMBOLS.....	1
MODEL, TEST TECHNIQUES, AND DATA REDUCTION.....	2
DISCUSSION.....	2
REFERENCES.....	3

ILLUSTRATIONS

- Table I Index of plotted data
- Figure 1 Sketch of Navy General Purpose Low Drag Bomb
- Figures 2-7 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, and -45 degrees Mach number 1.53
- Figures 8-13 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, -45 degrees Mach number 1.76
- Figures 14-19 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, -45 degrees Mach number 0.40
- Figures 20-25 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, -45 degrees Mach number 0.60
- Figures 26-31 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, -45 degrees Mach number 0.80
- Figures 32-37 C_N , C_θ , C_ψ , C_g , and C_A vs. α for $\theta = 0$, -22.5, -45 degrees Mach number 2.03

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WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT
ANGLES OF ATTACK UP TO 70 DEGREES

INTRODUCTION

1. The low-drag bomb is a standard Navy external store carried by high speed aircraft. The MK 81, 82, 83, and 84 bombs use the low-drag bomb shape as tested in this investigation.
2. This report gives the results of a wind-tunnel investigation to determine the stability and drag coefficients at high angles of attack (up to 70 degrees). The coefficients are necessary for trajectory calculations. The data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

AERODYNAMIC SYMBOLS

A	reference area (based on maximum body diameter)
c.g.	center of gravity, 3.64 calibers forward from the base
C_A	axial force coefficient (F_A/qA)
C_θ	pitching moment coefficient (M_θ/qAd)
C_N	normal force coefficient (F_N/qA)
C_Y	side force coefficient (F_Y/qA)
C_ϕ	rolling moment coefficient (M_ϕ/qAd)
C_ψ	yawing moment coefficient (M_ψ/qAd)
d	reference diameter (maximum body diameter = caliber) (1.5 in)
F_A	axial force (lbs)
F_N	normal force (lbs)
F_Y	side force (lbs)
M_θ	pitching moment (in-lbs)
M_ϕ	rolling moment (in-lbs)
M_ψ	yawing moment (in-lbs)
q	dynamic pressure (psi)

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NAVWEPS REPORT 7291

- α angle of attack (deg)
 θ angle of roll ($\theta = 0^\circ$ with fins in horizontal and vertical planes respectively) (deg)

MODEL, TEST TECHNIQUES, AND DATA REDUCTION

3. A sketch of the model is shown as Figure 1. The data were obtained using a six-component internal strain-gage balance (reference (n)). These data were recorded on IBM cards using the automatic data recording system explained in reference (o)). The IBM 704 machine was used to reduce the wind-tunnel data to coefficient form. A correction was made to the data for the elastic deflection of the sting due to the aerodynamic loading.

DISCUSSION

4. Six-component data were desired over a Mach number range from 0.40 to 2.03 at angles of attack up to 70 degrees. At the supersonic Mach numbers the model size restricted the maximum angle of attack. At a Mach number of 1.53, the maximum angle of attack was 10 degrees, Mach number 1.76 the maximum angle of attack, 12 degrees, and at Mach number 2.03 the maximum angle of attack, 30 degrees.

5. The data are plotted in coefficient form versus angle of attack in Figures 2 through 37. An index of the plotted data is presented in Table I.

NAVWEPS REPORT 7291

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- (o) Gilbert, B. D., "Automatic Data Processing System (ADAPS) for the Supersonic Wind Tunnels," NAVORD Report 2813, Unclassified, (1953)

NAVWEPS REPORT 7291

TABLE I
INDEX OF PLOTTED DATA

Figure No.	Run Number	Mach No.	θ deg	α deg	Coefficients Plotted
2	8	1.53	-45	0-10	C_N , C_Q , C_Y , C_ψ
3	8	1.53	-45	0-10	C_θ , C_A
4	9	1.53	-22.5	0-10	C_N , C_Q , C_Y , C_ψ
5	9	1.53	-22.5	0-10	C_θ , C_A
6	10	1.53	0	0-10	C_N , C_Q , C_Y , C_ψ
7	10	1.53	0	0-10	C_θ , C_A
8	7	1.76	-45	0-12	C_N , C_Q , C_Y , C_ψ
9	7	1.76	-45	0-12	C_θ , C_A
10	6	1.76	-22.5	0-12	C_N , C_Q , C_Y , C_ψ
11	6	1.76	-22.5	0-12	C_θ , C_A
12	5	1.76	0	0-12	C_N , C_Q , C_Y , C_ψ
13	5	1.76	0	0-12	C_θ , C_A
14	18,20,21	0.40	-45	0-70	C_N , C_Q , C_Y , C_ψ
15	18,20,21	0.40	-45	0-70	C_θ , C_A
16	19,22	0.40	-22.5	0-70	C_N , C_Q , C_Y , C_ψ
17	19,22	0.40	-22.5	0-70	C_θ , C_A
18	23	0.40	0	30-70	C_N , C_Q , C_Y , C_ψ

NAVWEPS REPORT 7291

TABLE I (Cont.d)

Figure No.	Run Number	Mach No.	θ deg	α deg	Coefficients Plotted
19	23	0.40	0	30-70	C_{θ} , C_A
20	17, 27, 34	0.60	-45	0-70	C_N , C_Q , C_Y , C_ψ
21	17, 27, 34	0.60	-45	0-70	C_{θ} , C_A
22	16, 26	0.60	-22.5	0-70	C_N , C_Q , C_Y , C_ψ
23	16, 26	0.60	-22.5	0-70	C_{θ} , C_A
24	15, 24, 25, 33	0.60	0	0-70	C_N , C_Q , C_Y , C_ψ
25	15, 24, 25 33	0.60	0	0-70	C_{θ} , C_A
26	28, 31	0.80	-45	29-70	C_N , C_Q , C_Y , C_ψ
27	28, 31	0.80	-45	29-70	C_{θ} , C_A
28	12, 29	0.80	-22.5	0-70	C_N , C_Q , C_Y , C_ψ
29	12, 29	0.80	-22.5	0-70	C_{θ} , C_A
30	11, 13, 14, 30, 32	0.80	0	0-70	C_N , C_Q , C_Y , C_ψ
31	11, 13, 14, 30, 32	0.80	0	0-70	C_{θ} , C_A
32	1, 2	2.03	-45	-6-30	C_N , C_Q , C_Y , C_ψ
33	1, 2	2.03	-45	-6-30	C_{θ} , C_A
34	3	2.03	-22.5	-0-30	C_N , C_Q , C_Y , C_ψ
35	3	2.03	-22.5	-0-30	C_{θ} , C_A
36	4	2.03	0	-0-30	C_N , C_Q , C_Y , C_ψ
37	4	2.03	0	-0-30	C_{θ} , C_A

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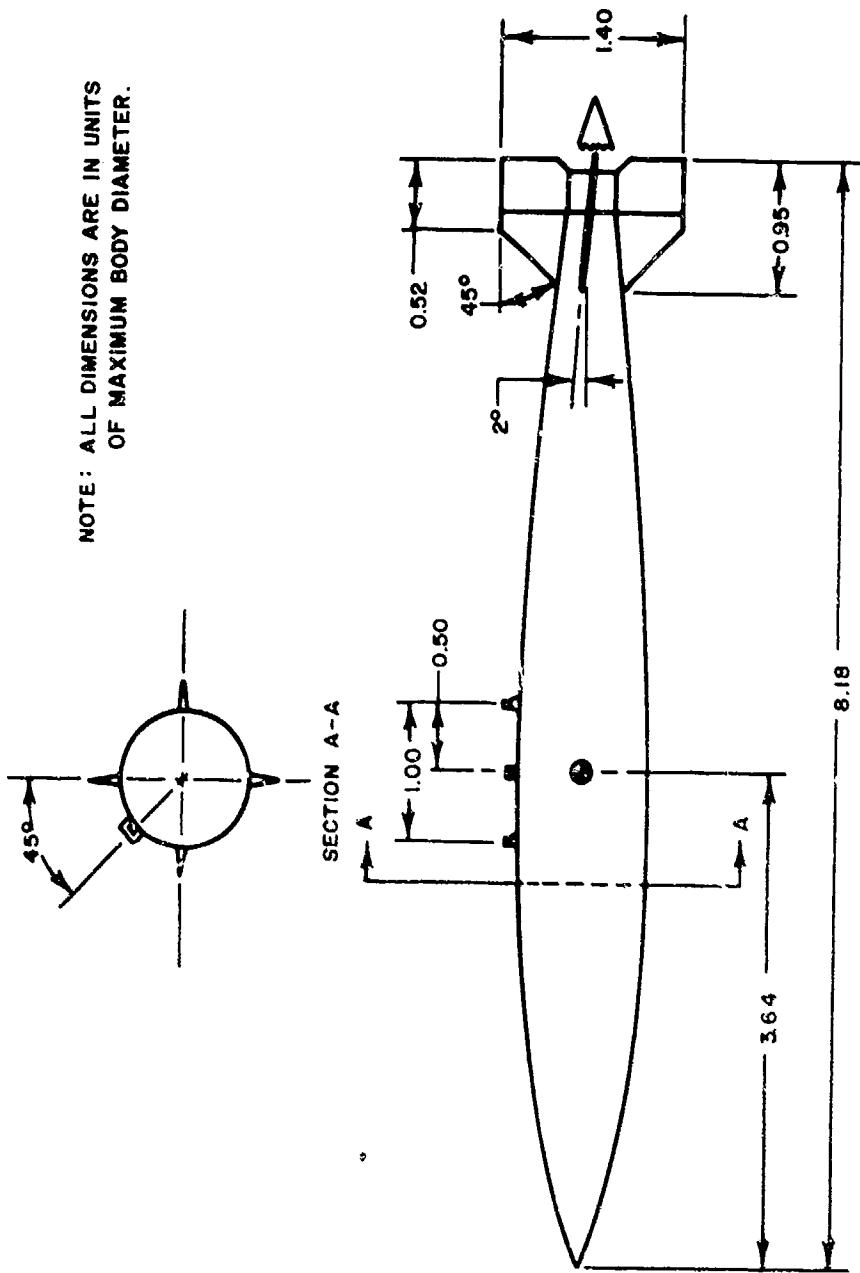
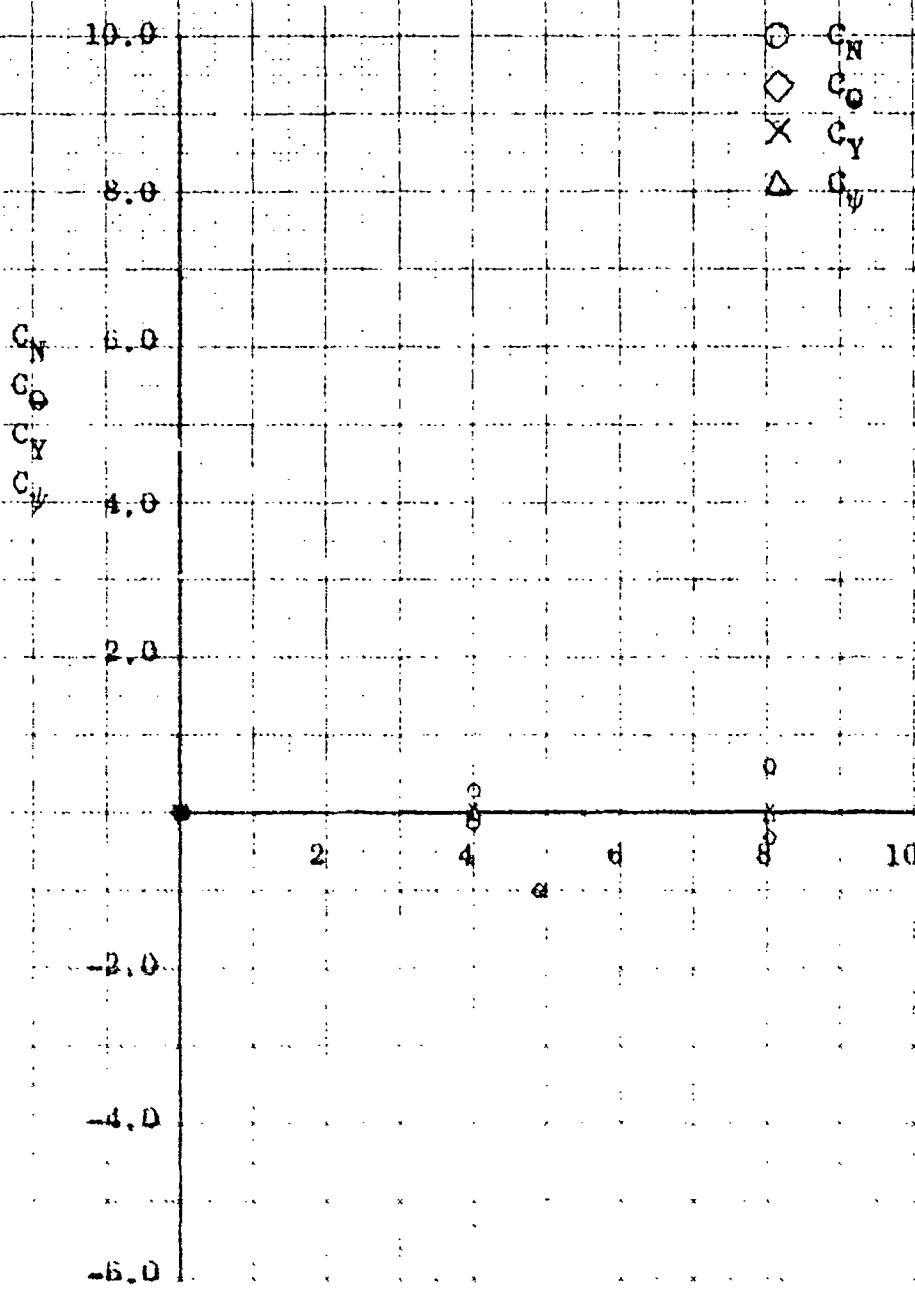


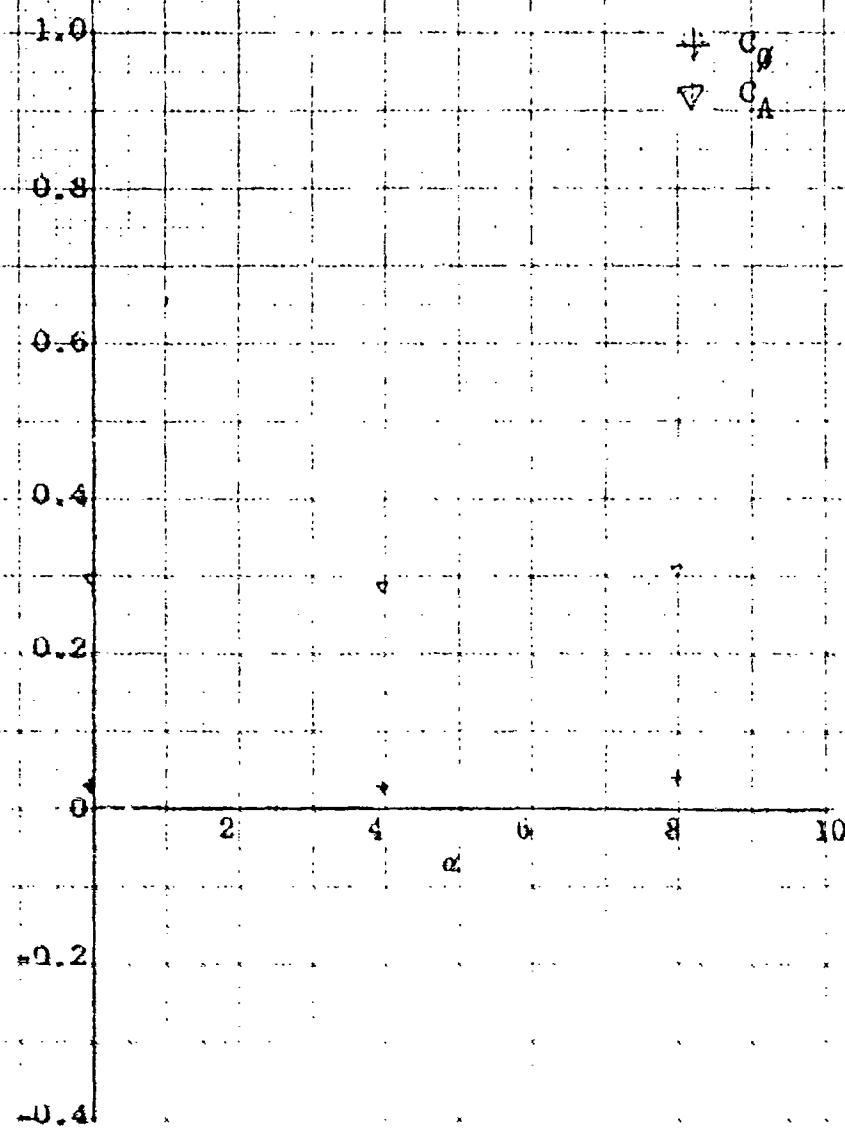
FIG. I U.S. NAVY GENERAL PURPOSE LOW DRAG BOMB

LOW DRAG BOMB

 $\theta = -45$
 $M = 1.53$ FIG. 2 C_N , C_Q , C_Y , C_P vs. α

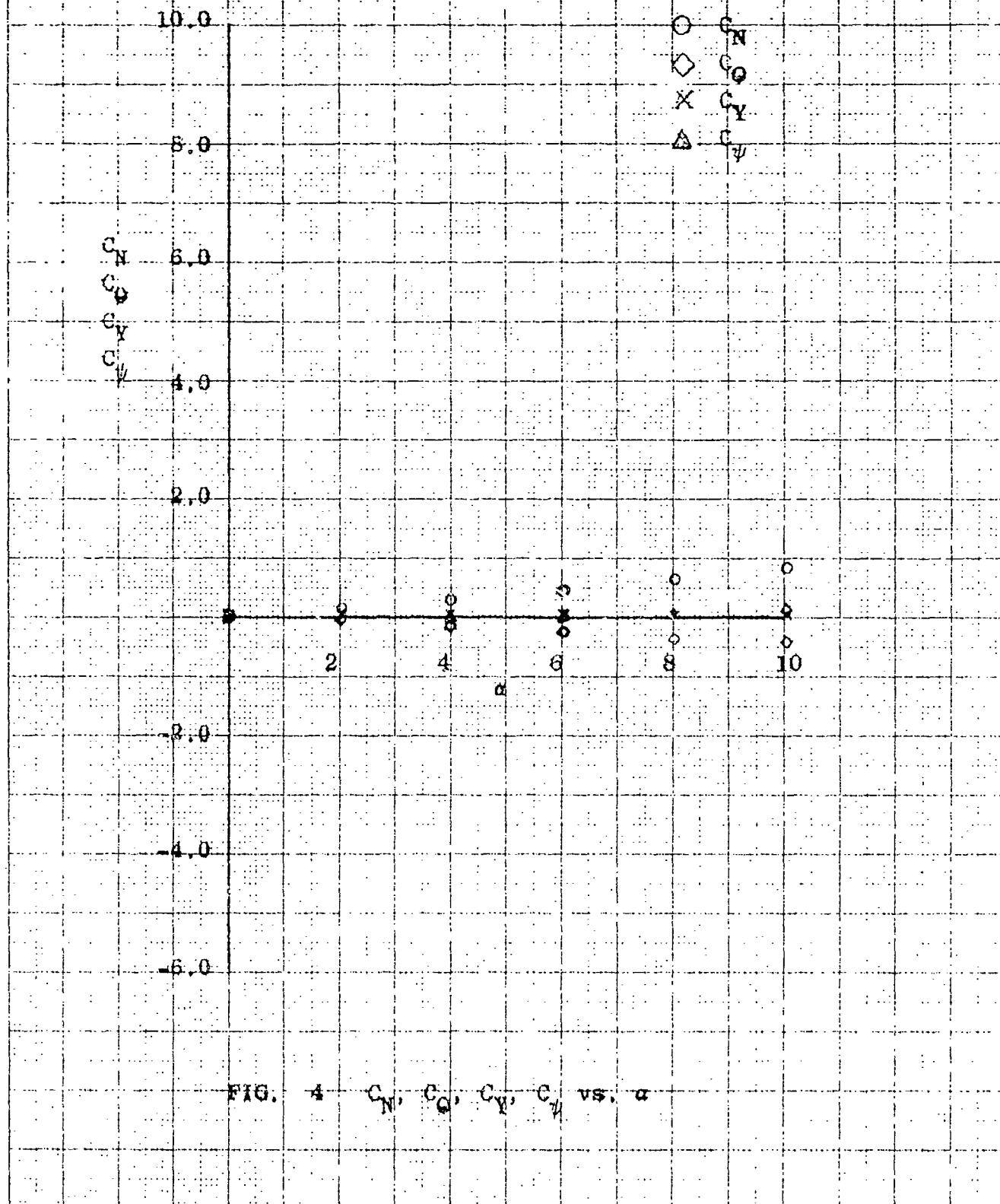
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LOW DRAG BOMB

 $\theta = -45$
 $M = 1.53$ FIG. 3 C_g, C_A vs. α

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LOW FRAG BOMB

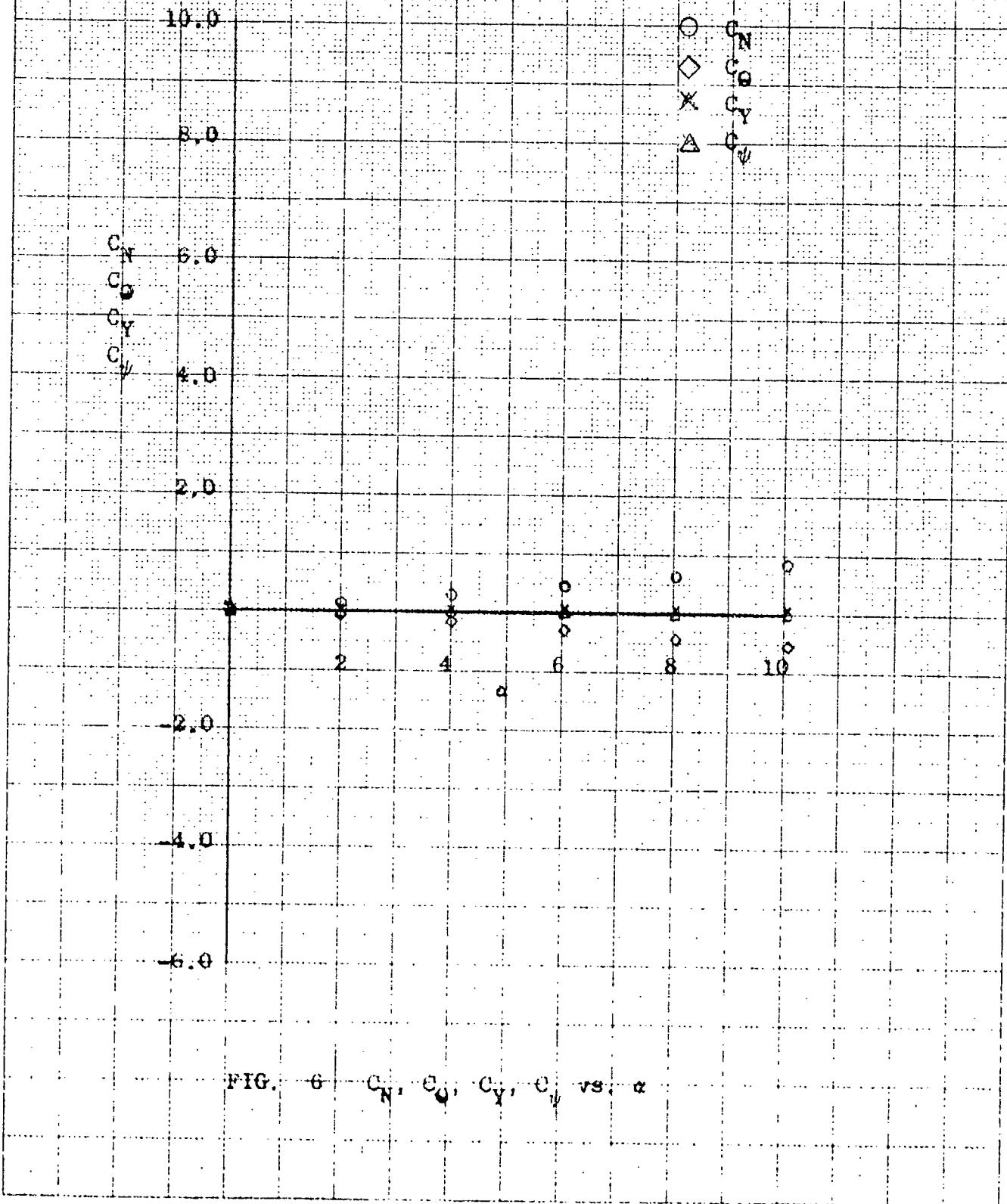
 $\theta = -22.5$ $M = 1.53$ 

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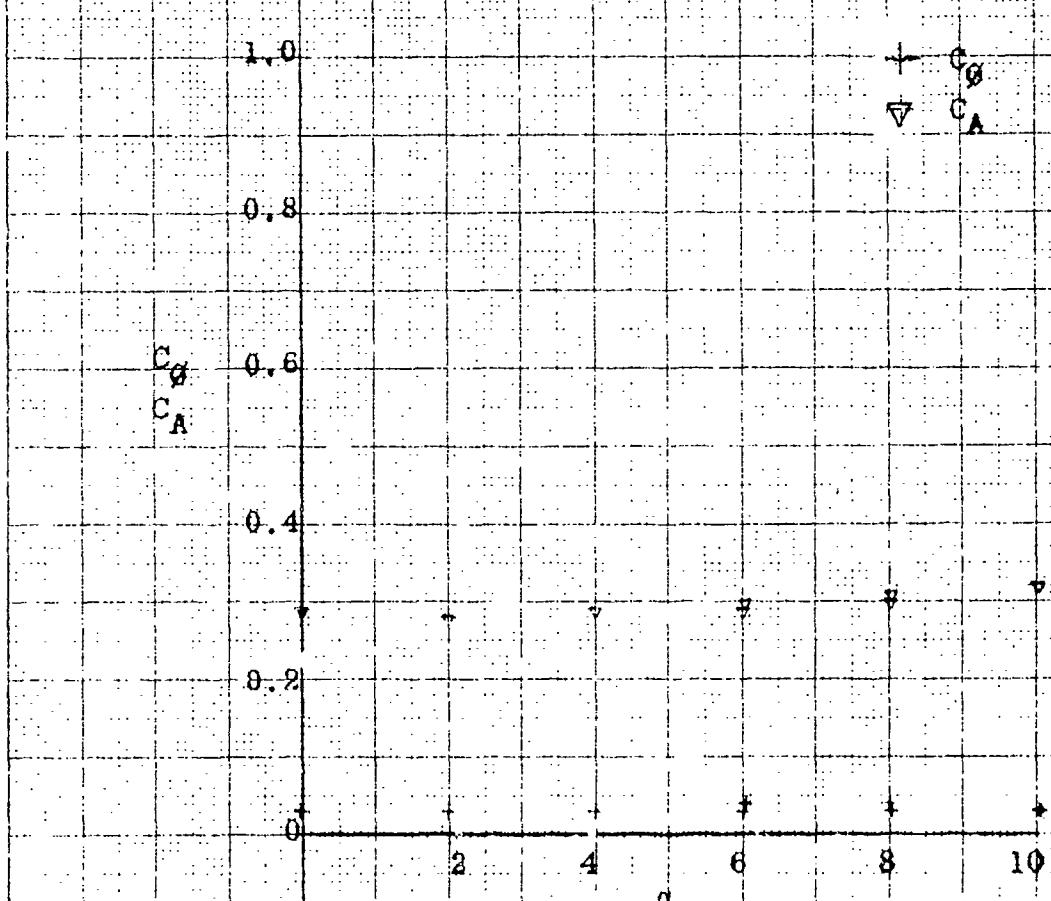
LOW DRAG BOMB

$$\theta = 0$$

$$M = 1.53$$

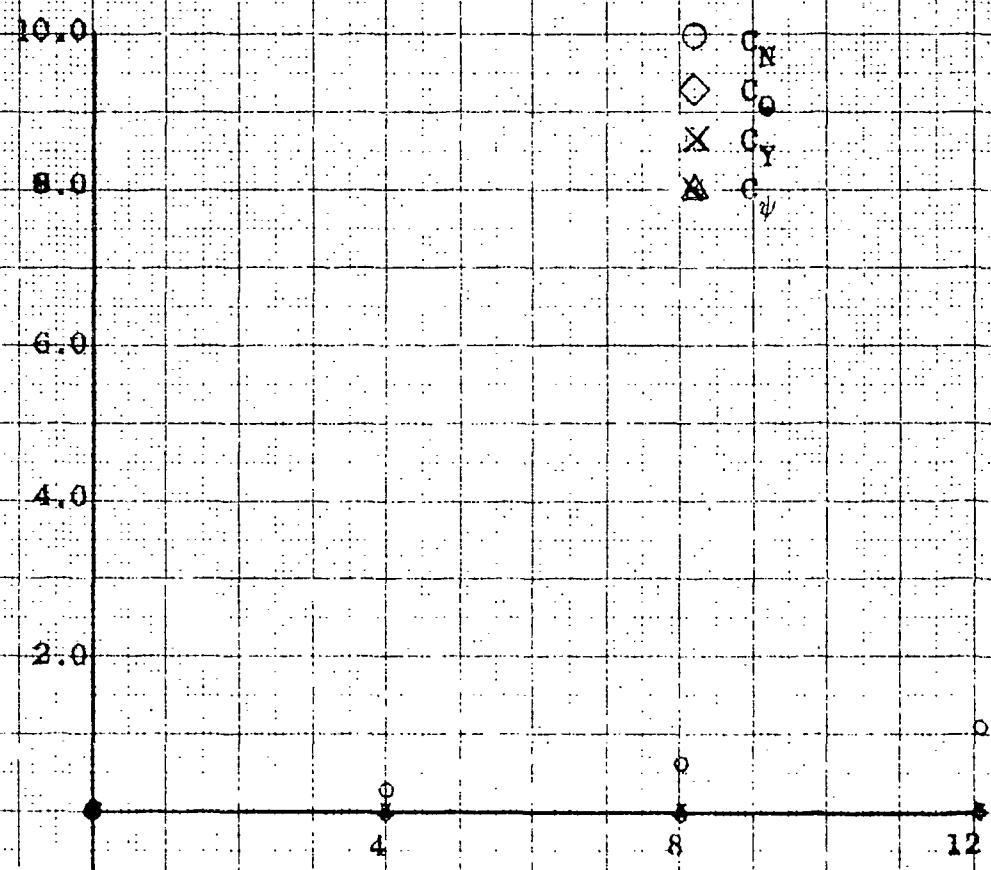


LOW DRAG BOMB

 $\theta = 10^\circ$
 $M = 1.53$ FIG. 7. C_D , C_A vs. M

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LOW DRAG BOMB

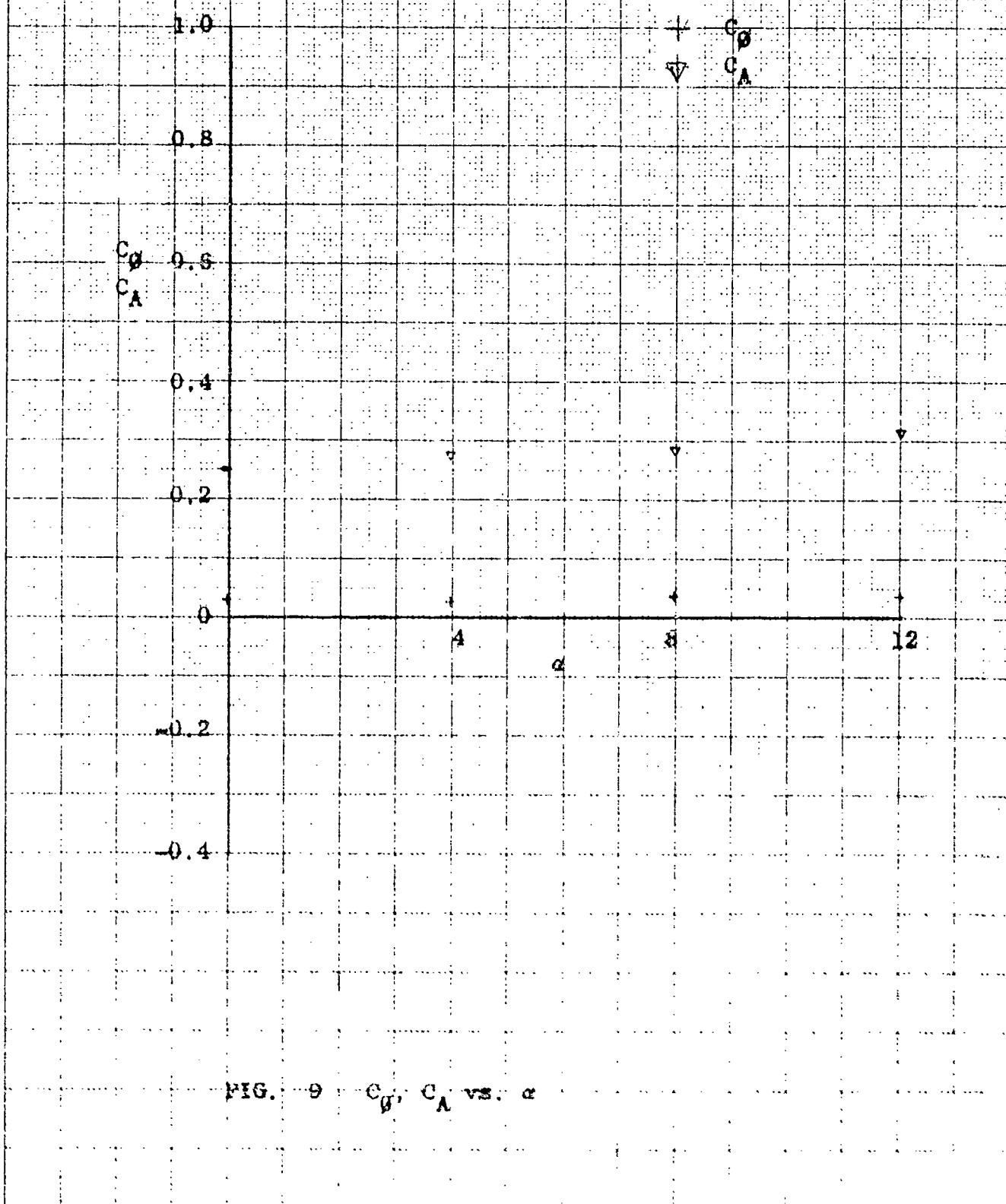
 $\theta = -45$
 $M = 1.76$ FIG. 8 C_N, C_Q, C_Y, C_V vs. α

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LOW DRAG BOMB

$$\theta = -45^\circ$$

$$M = 1.76$$

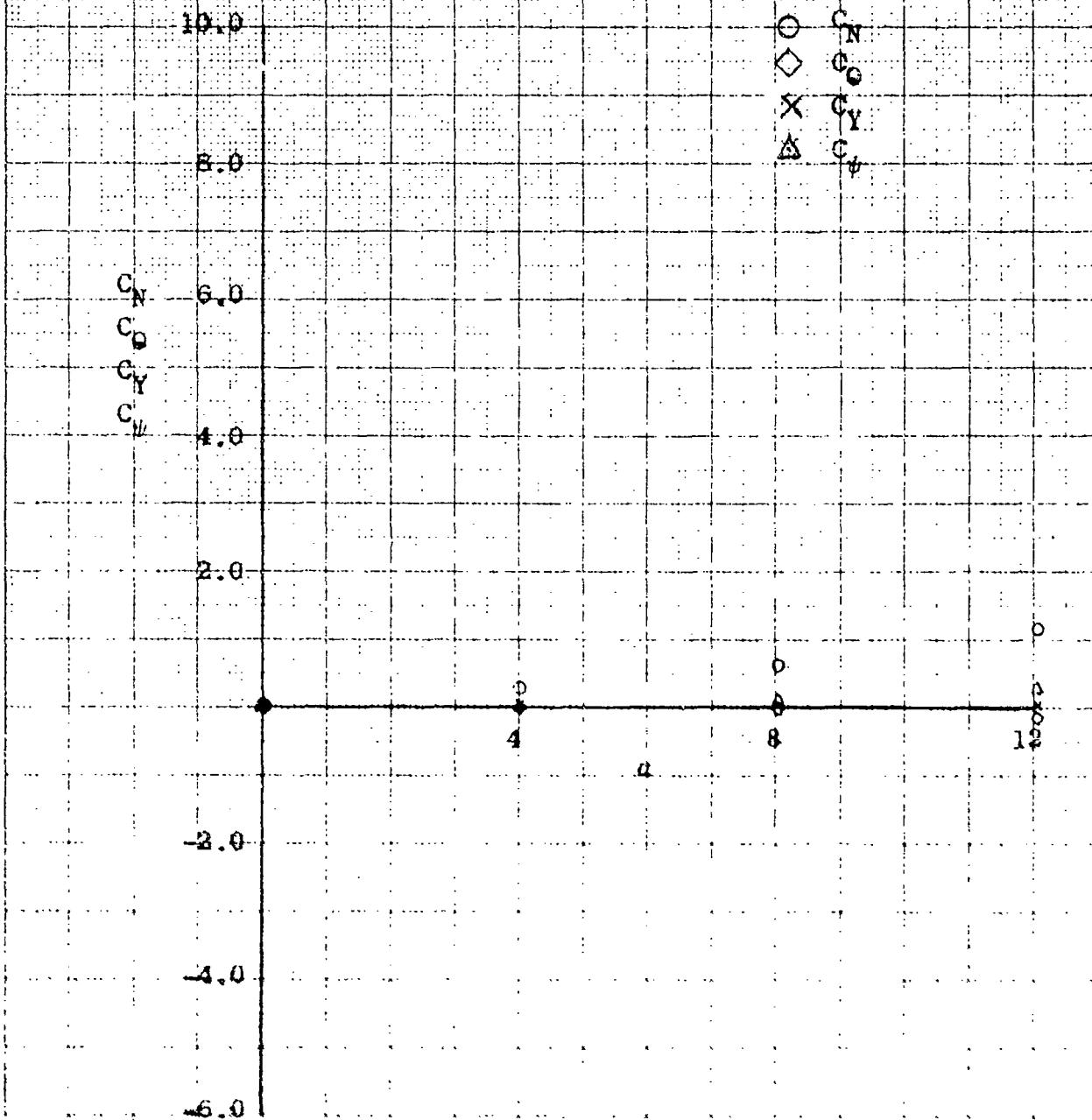


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LOW DRAG BOMB

$$\theta = -22.5$$

$$M = 1.76$$

FIG. 10. C_N , C_D , C_Y , C_ϕ vs. θ

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LOW DRAG BOMB

$$\theta = -22.5$$

$$M = 1.76$$

1.0

0.8

0.6

0.4

0.2

0

-0.2

-0.4

-0.6

-0.8

-1.0

 C_D
 C_A

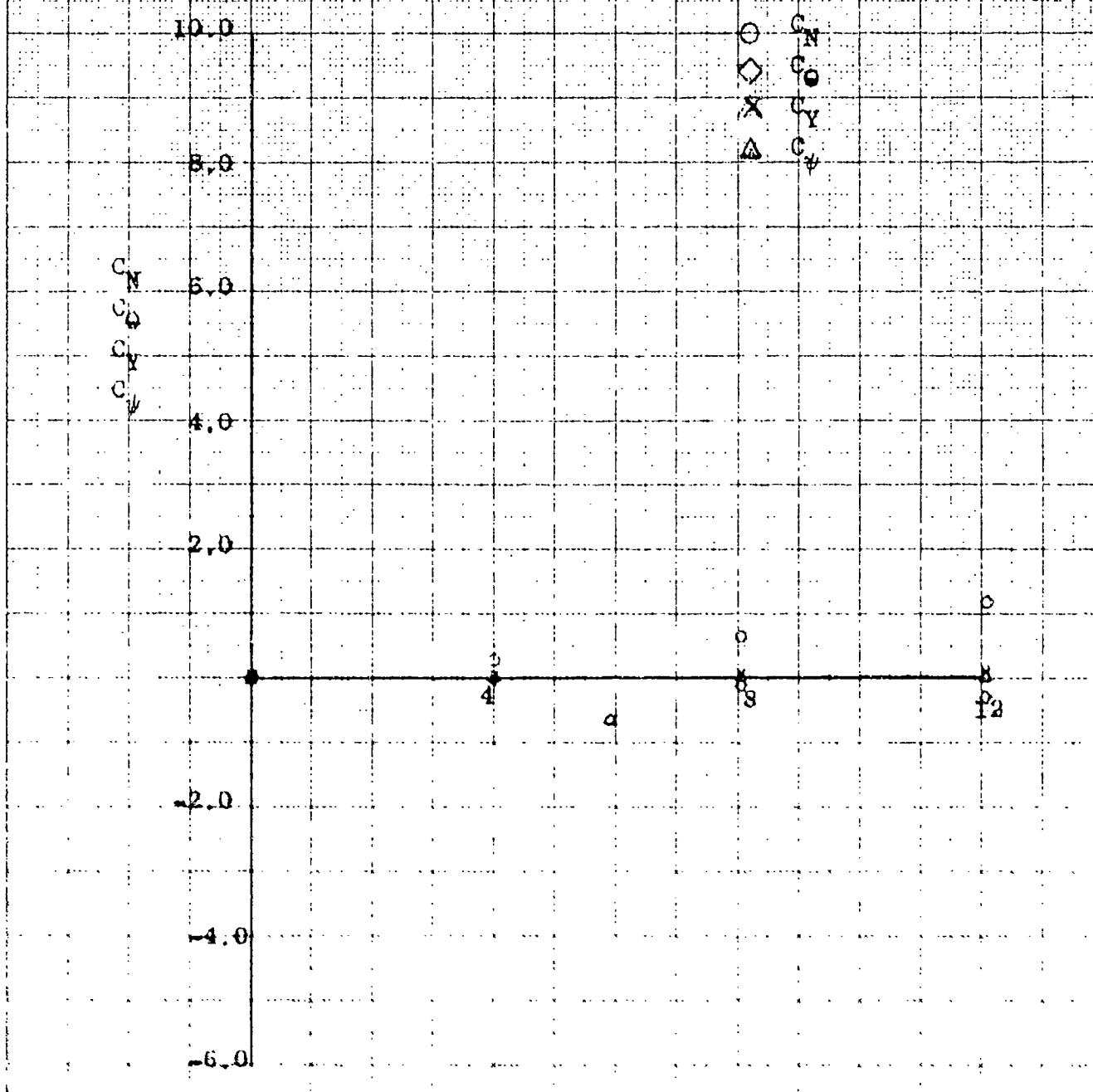
4 8 12

a

FIG. 11. C_D , C_A vs. a .

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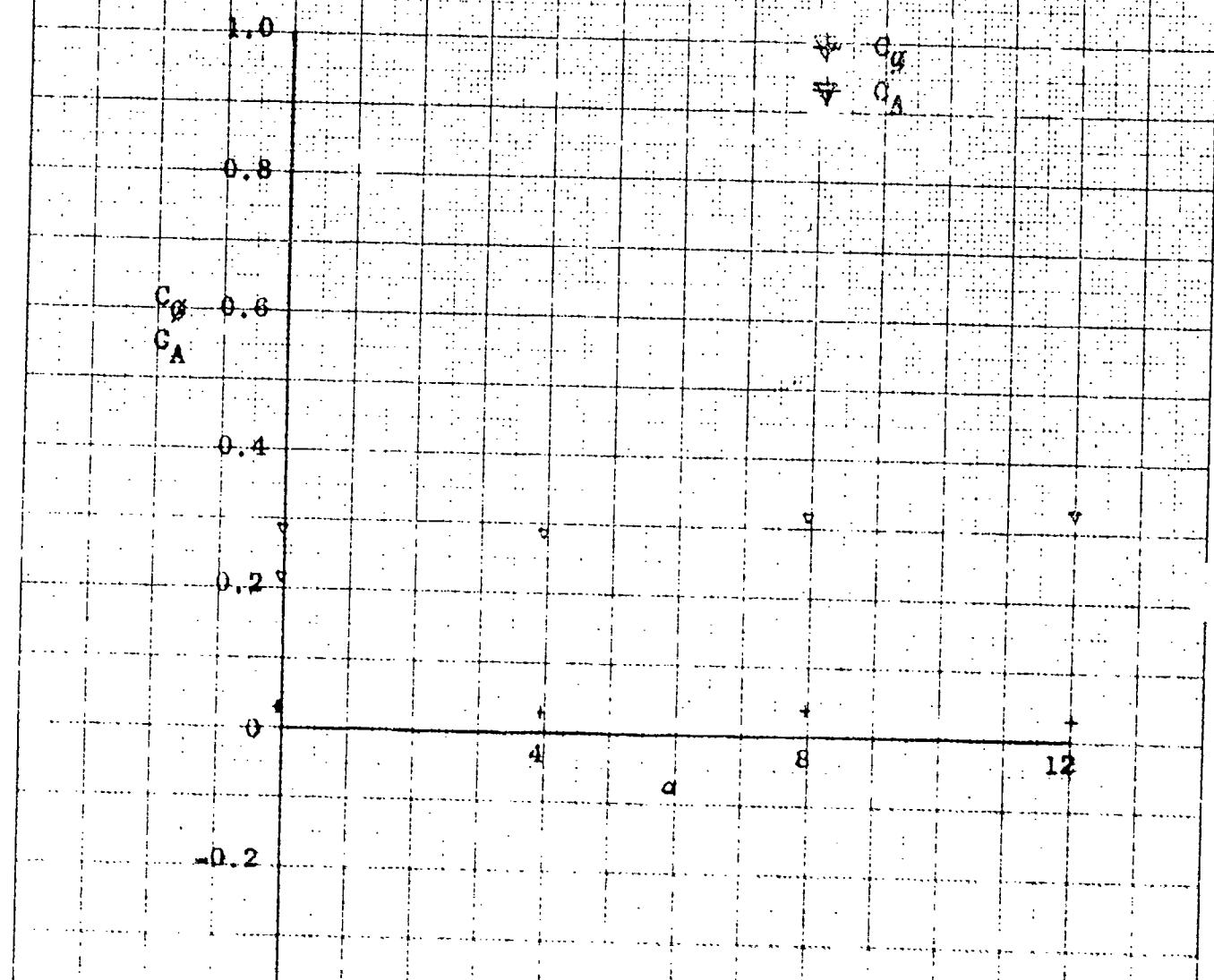
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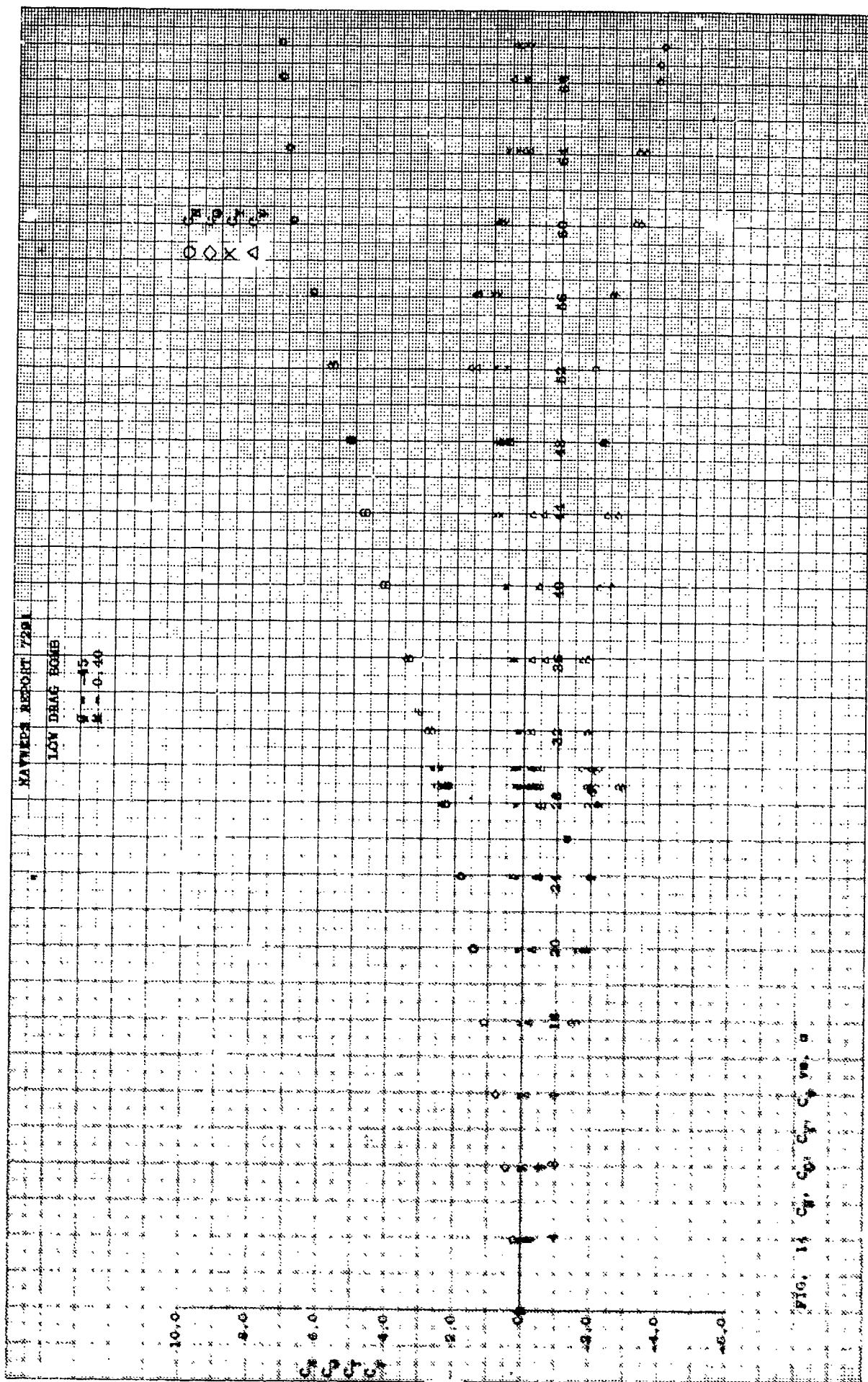
 $\theta = 0$
 $M = 1.76$ FIG. 12: C_N , C_G , C_Y , C_V vs. α

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LOW DRAG BOMB

$$\theta = 0$$
$$M = 1.76$$

FIG. 13 C_g, C_a vs. α



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BALTIMORE REPORT 7281

DOV DRAG BOMB

G - 45
H - 0.40

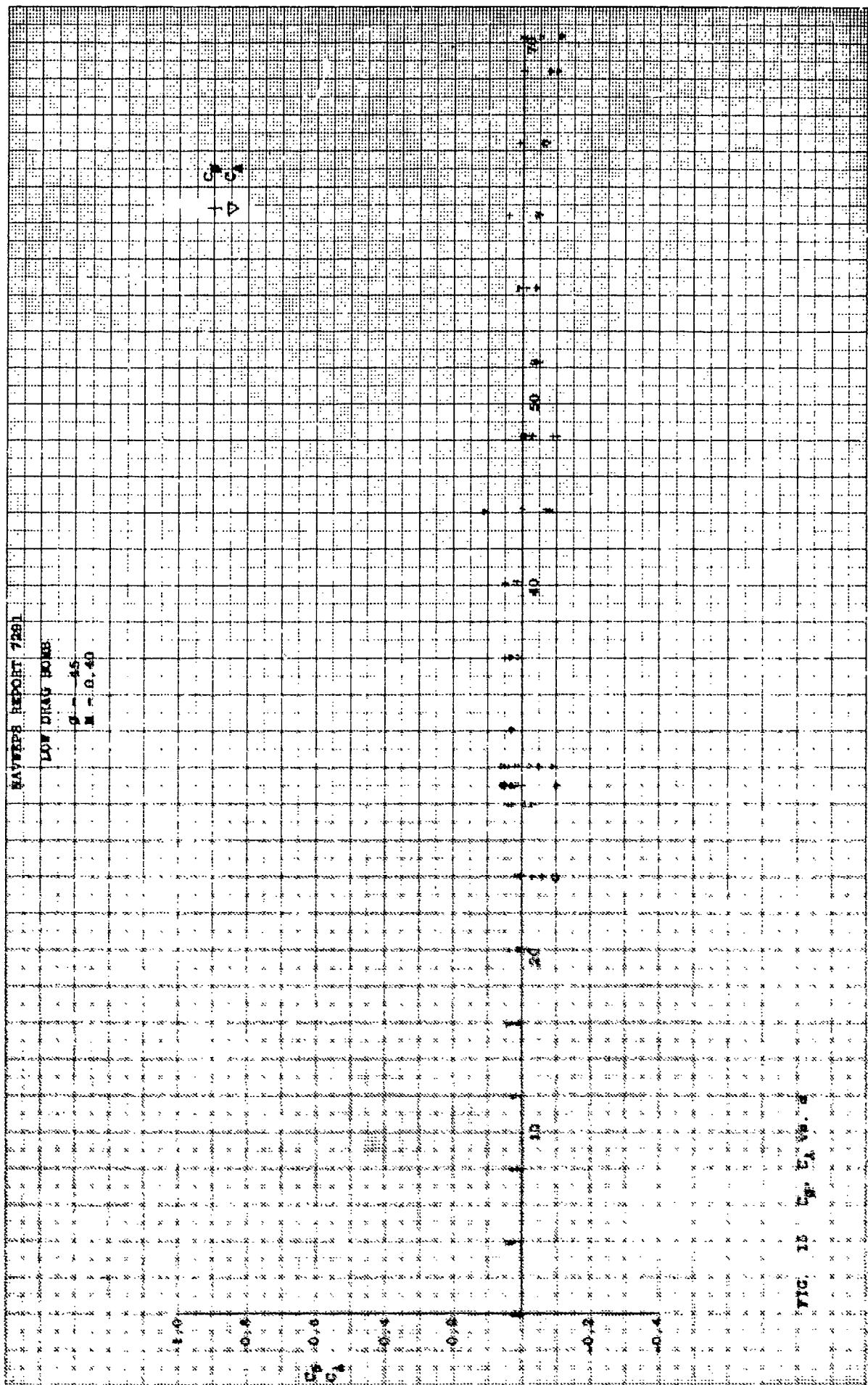


FIG. 10 C. E. V.

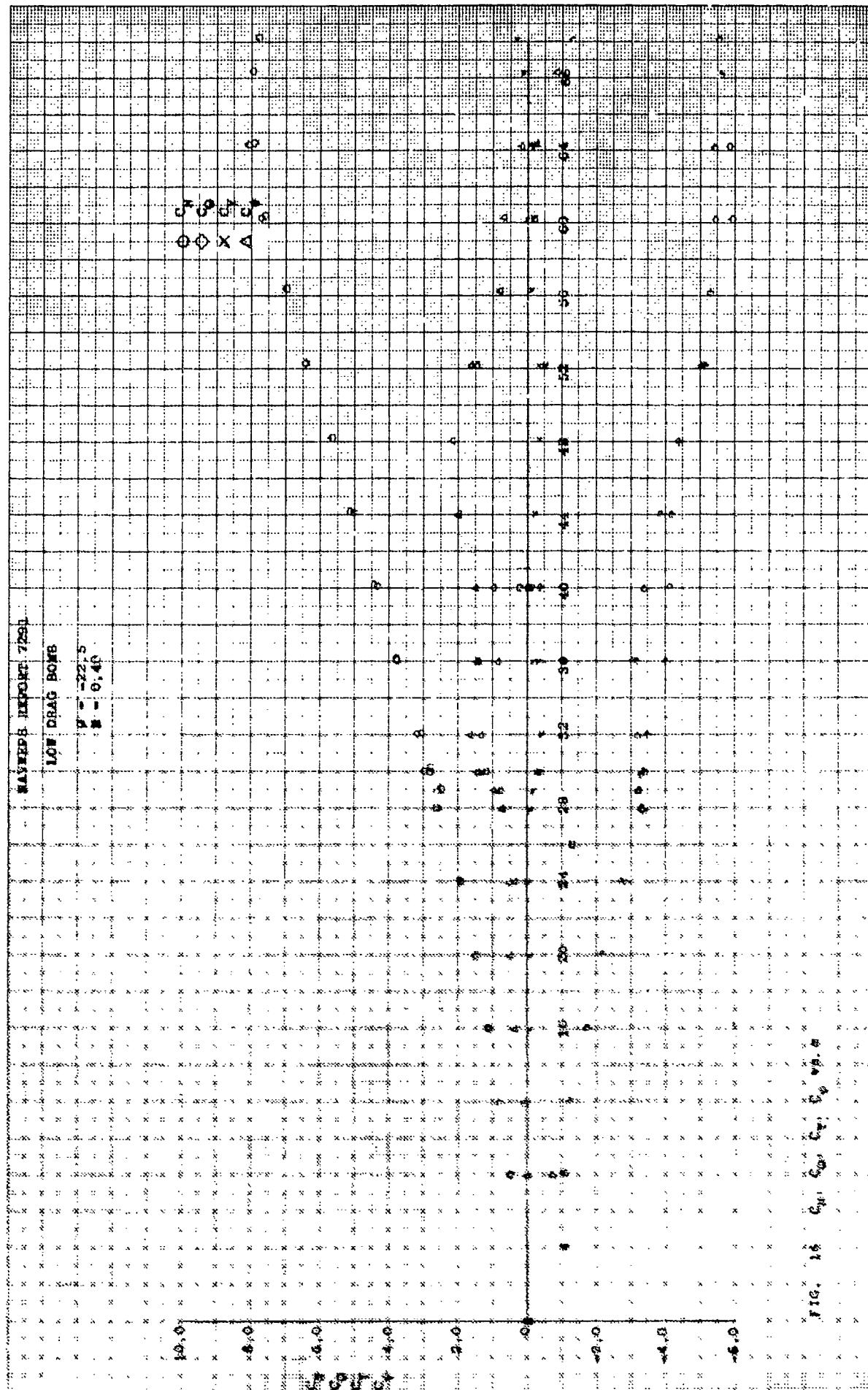
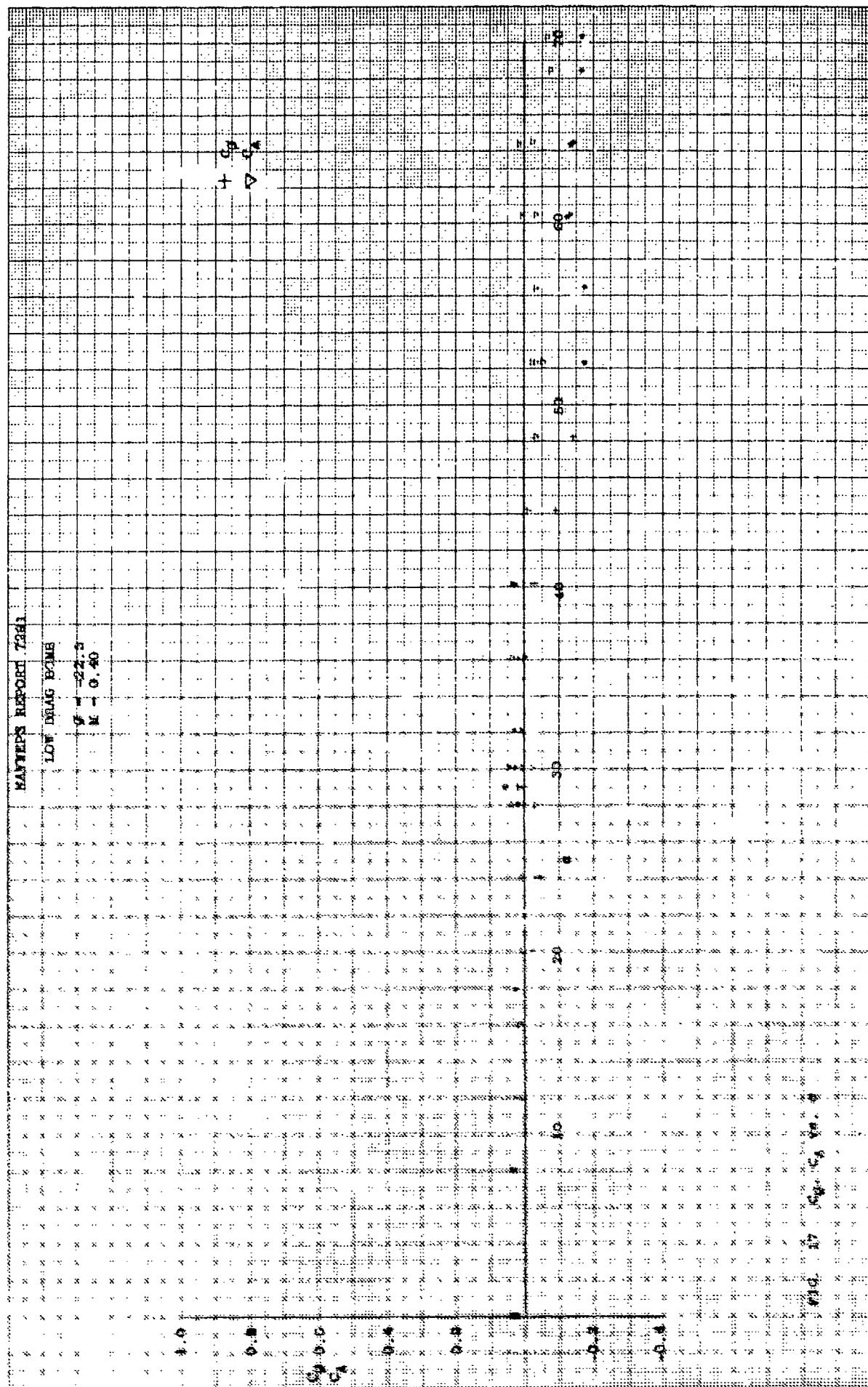


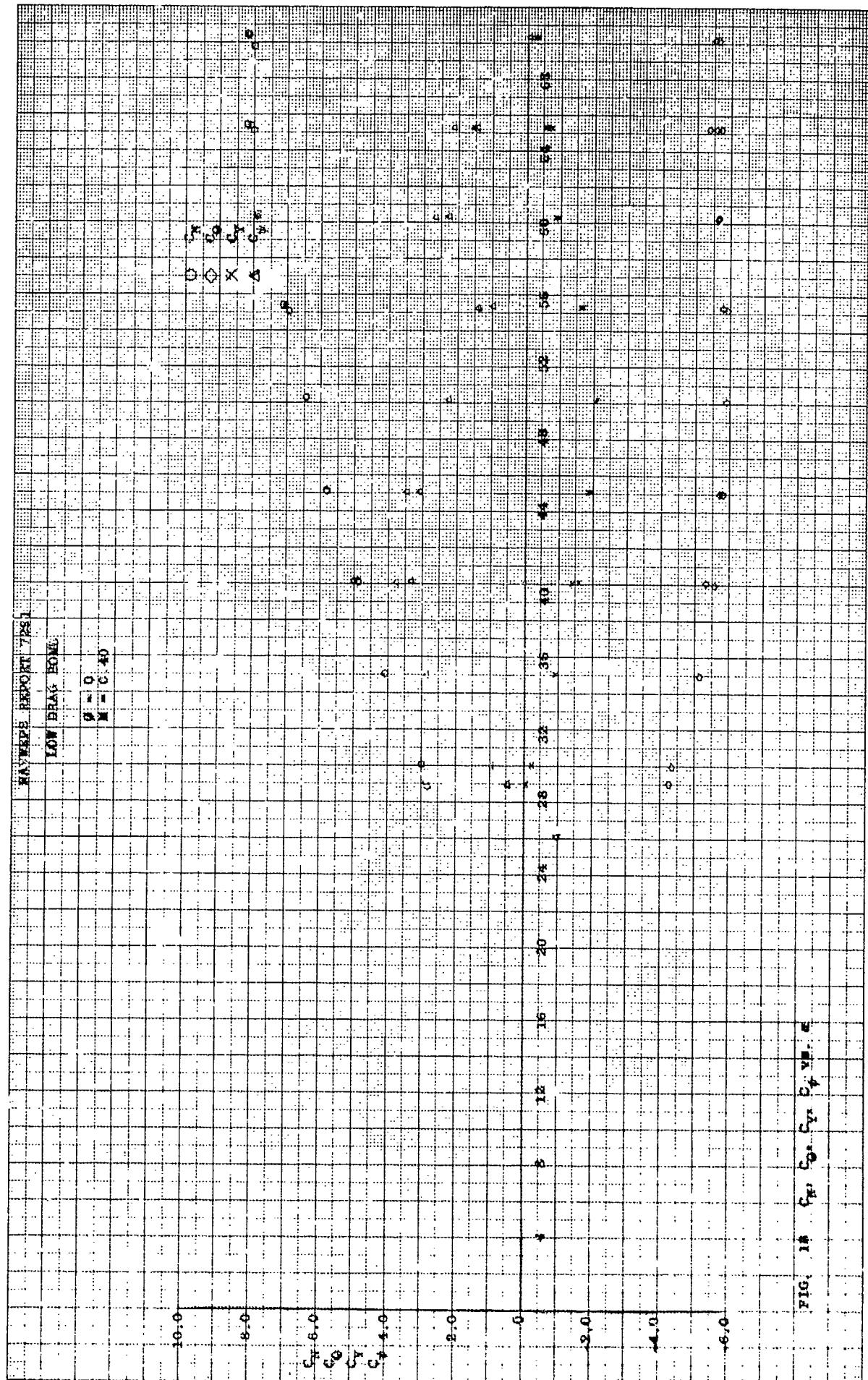
FIG. 16. ON SET OF DATA.

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HAWTHORN'S REPORT [722]

LOW DRAG BOMB

$$B = 0$$

$$M = 0.40$$

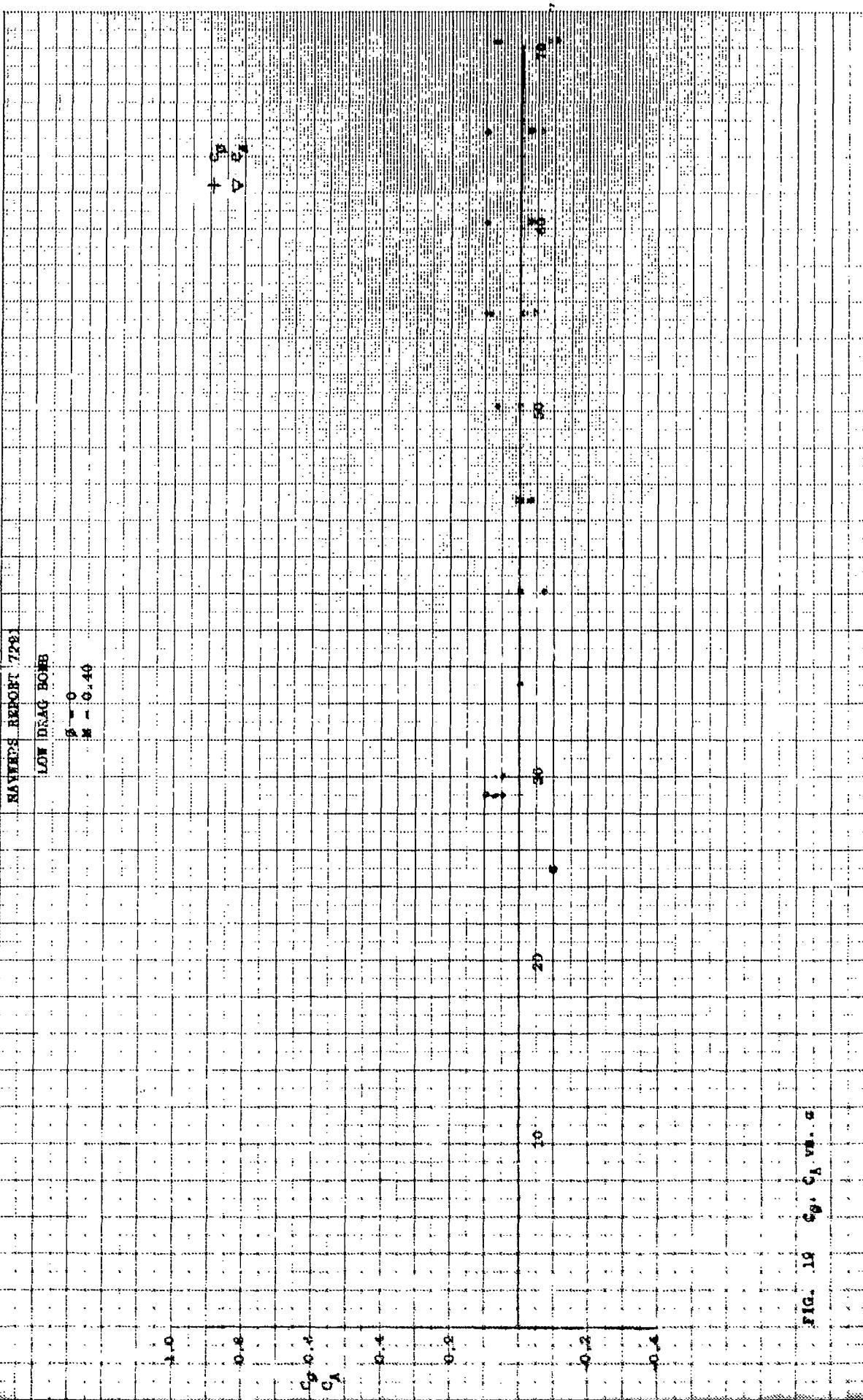


FIG. 19 Cg, Ca vs. a

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LOW DRAG BOBB

$C_D = 0.5$
 $M = 0.6$

10.0
8.0
6.0
4.0
2.0
0.0

0

10

20

30

40

50

60

70

80

90

100

110

120

130

140

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320

330

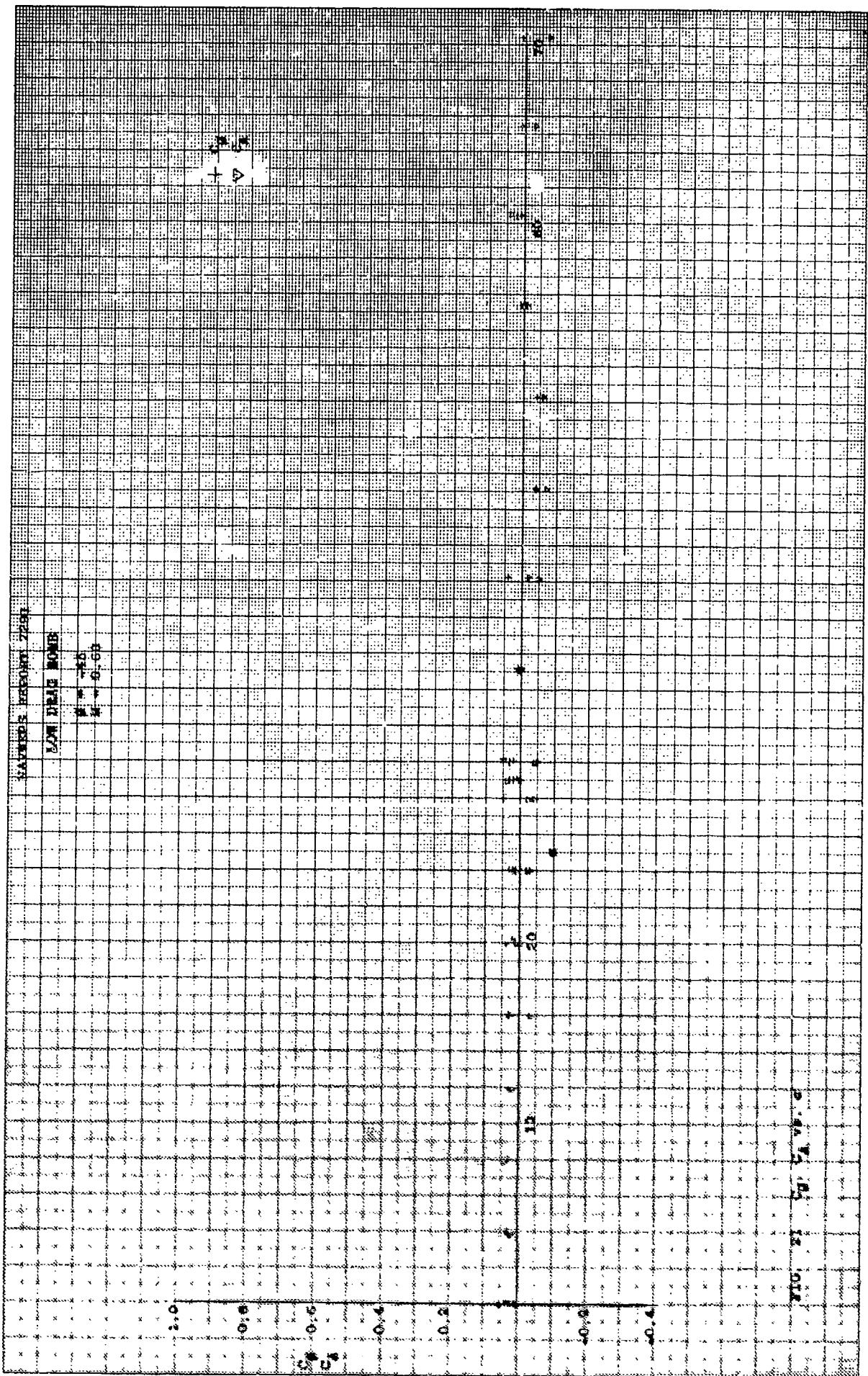
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350

C_D

K-2
300 T 100

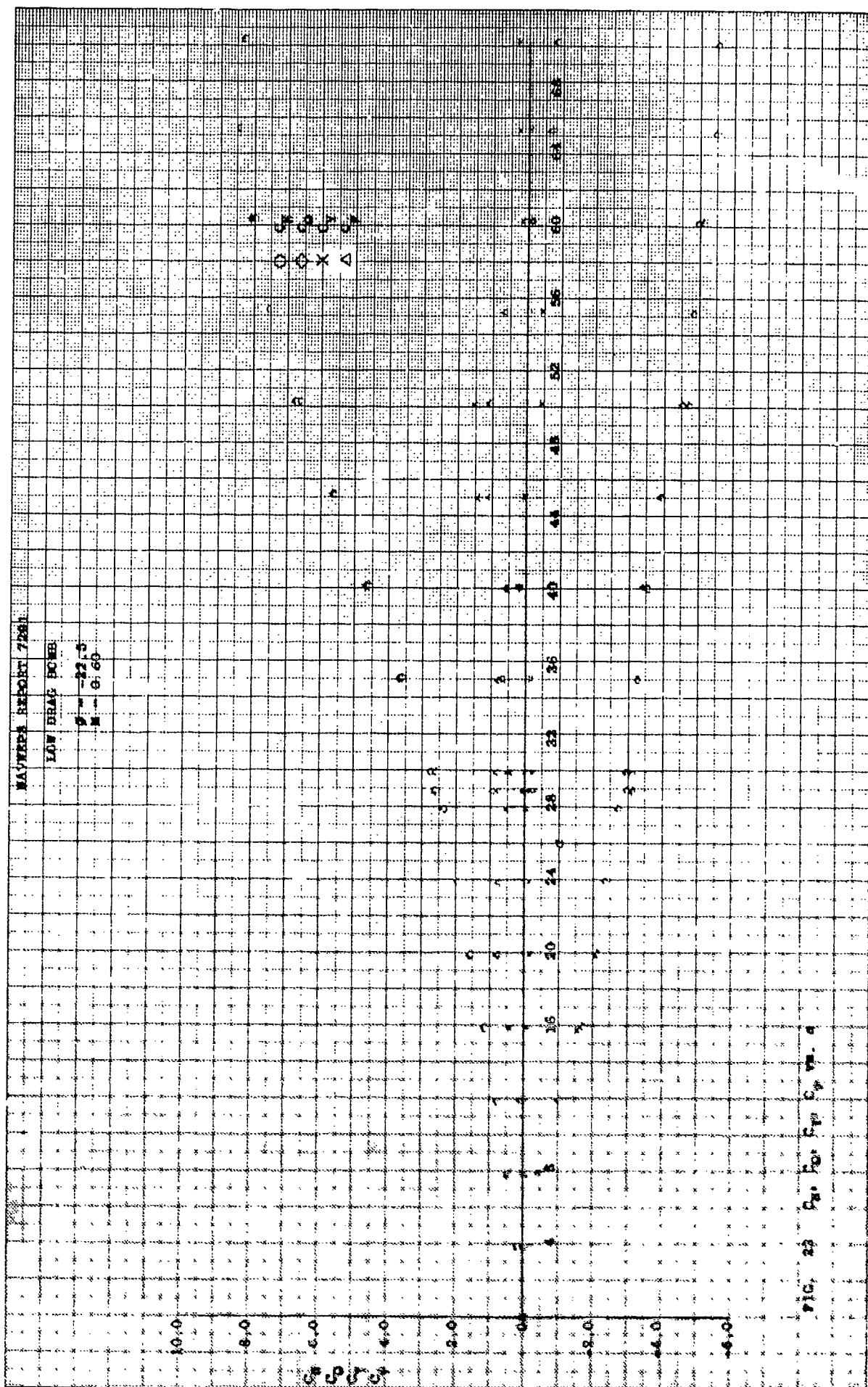
FIG. 20 C_D vs. C_{DR}



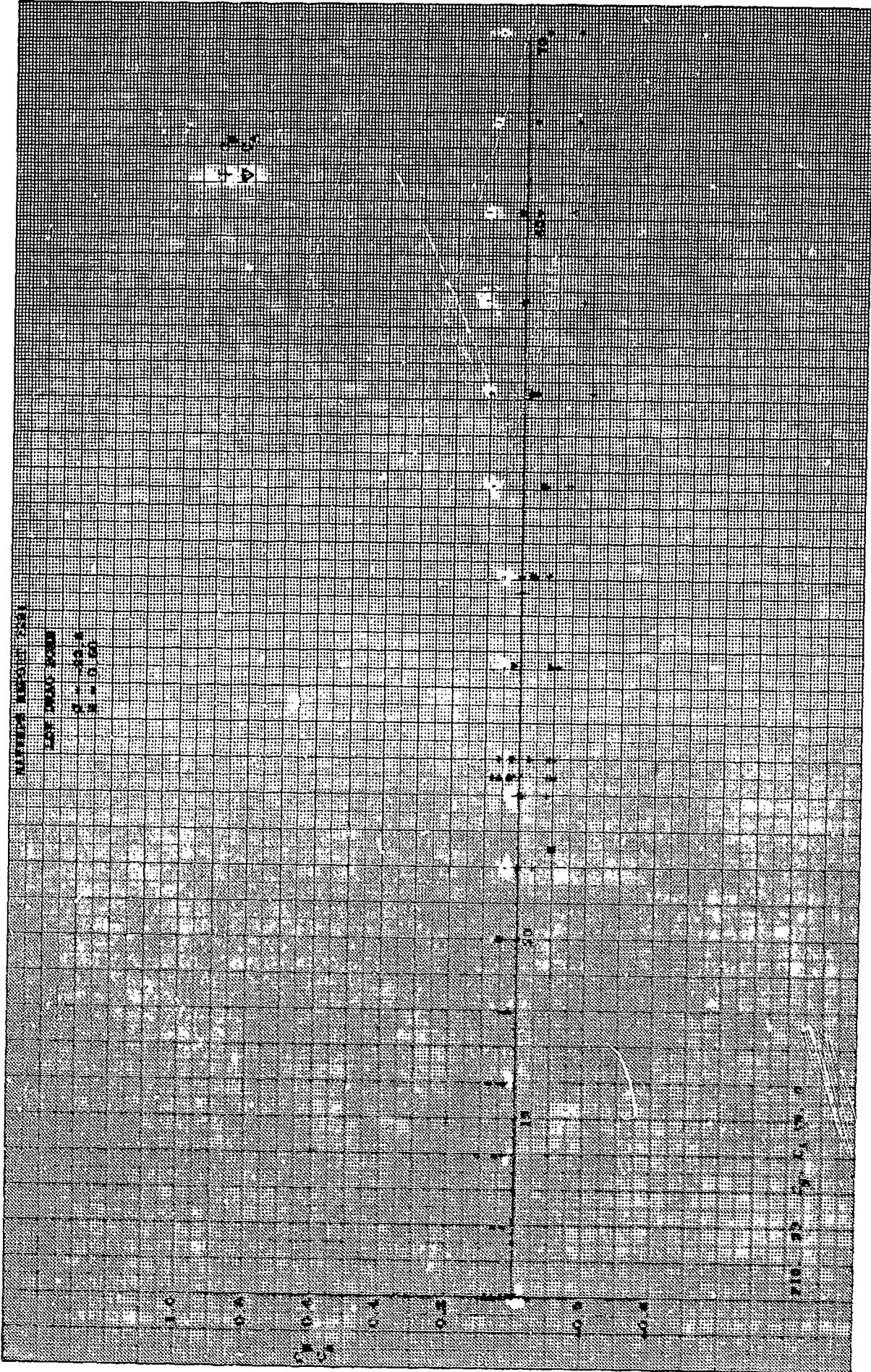
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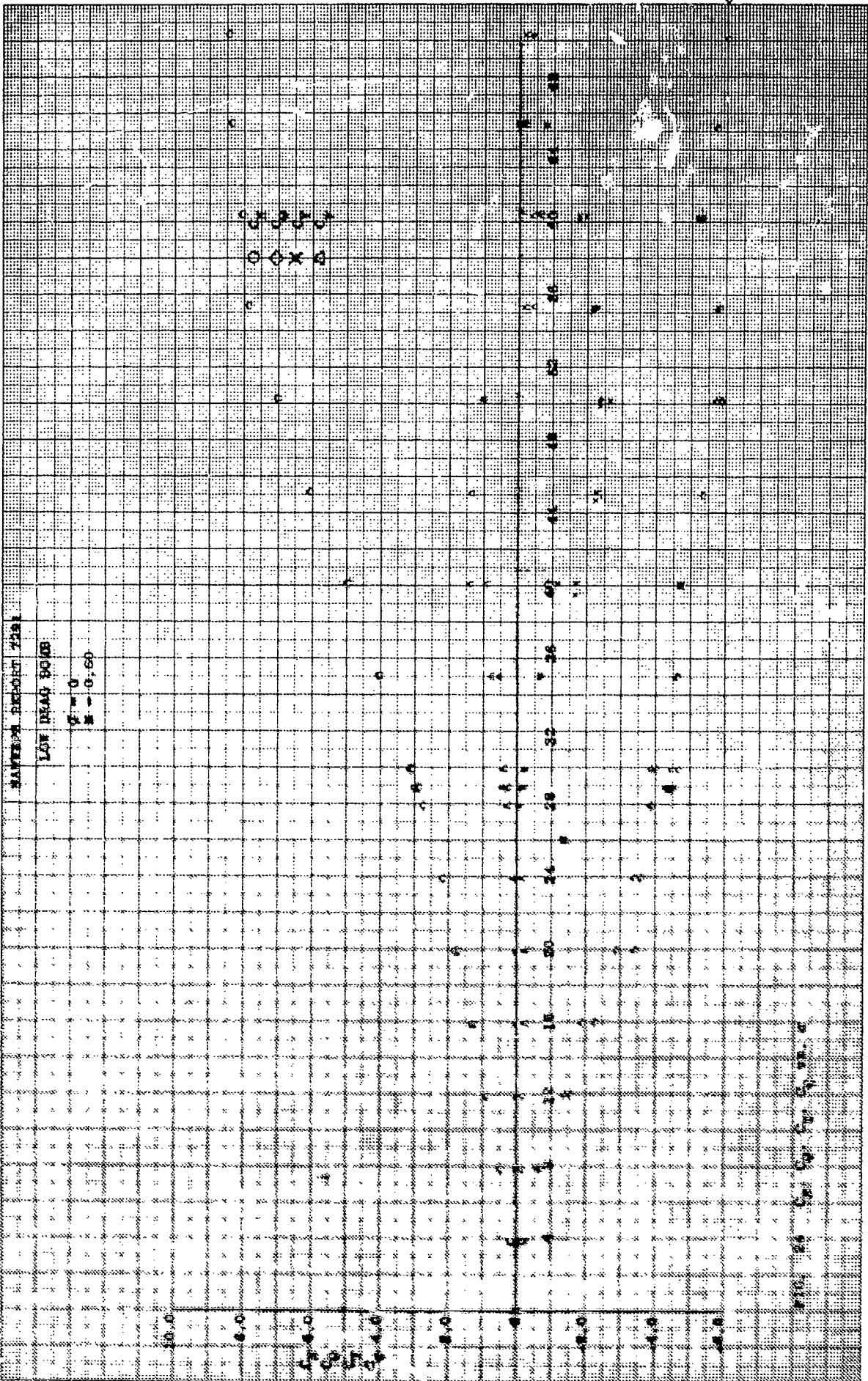
LOW DRAG BOMB

D = -22.3
H = 0.60



PAGE 23 FOR FPN 207-4





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LOW DRAG BOMB

$$\frac{C_D}{C_A} = 0.69$$

$$\frac{C_D}{C_A}$$

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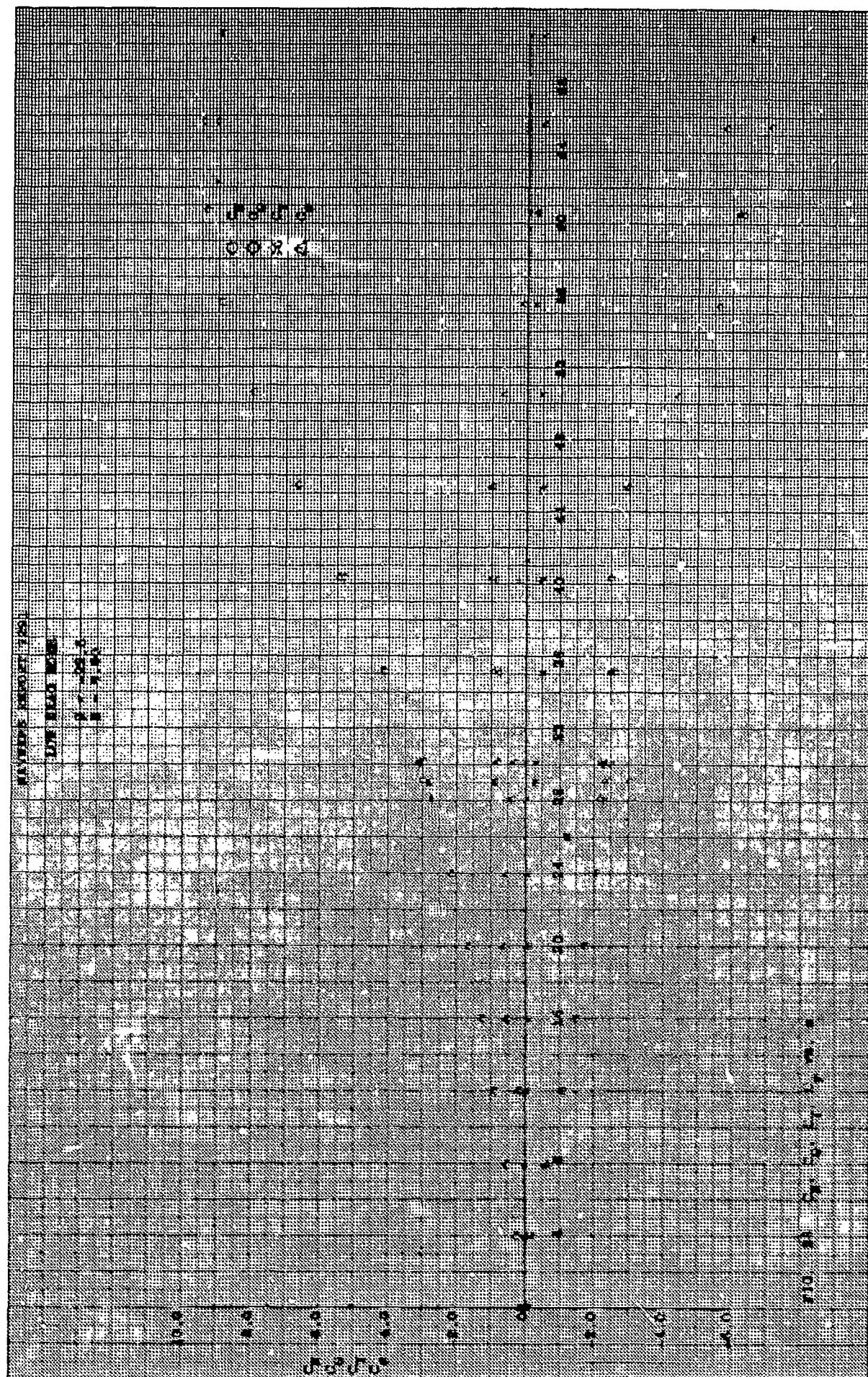
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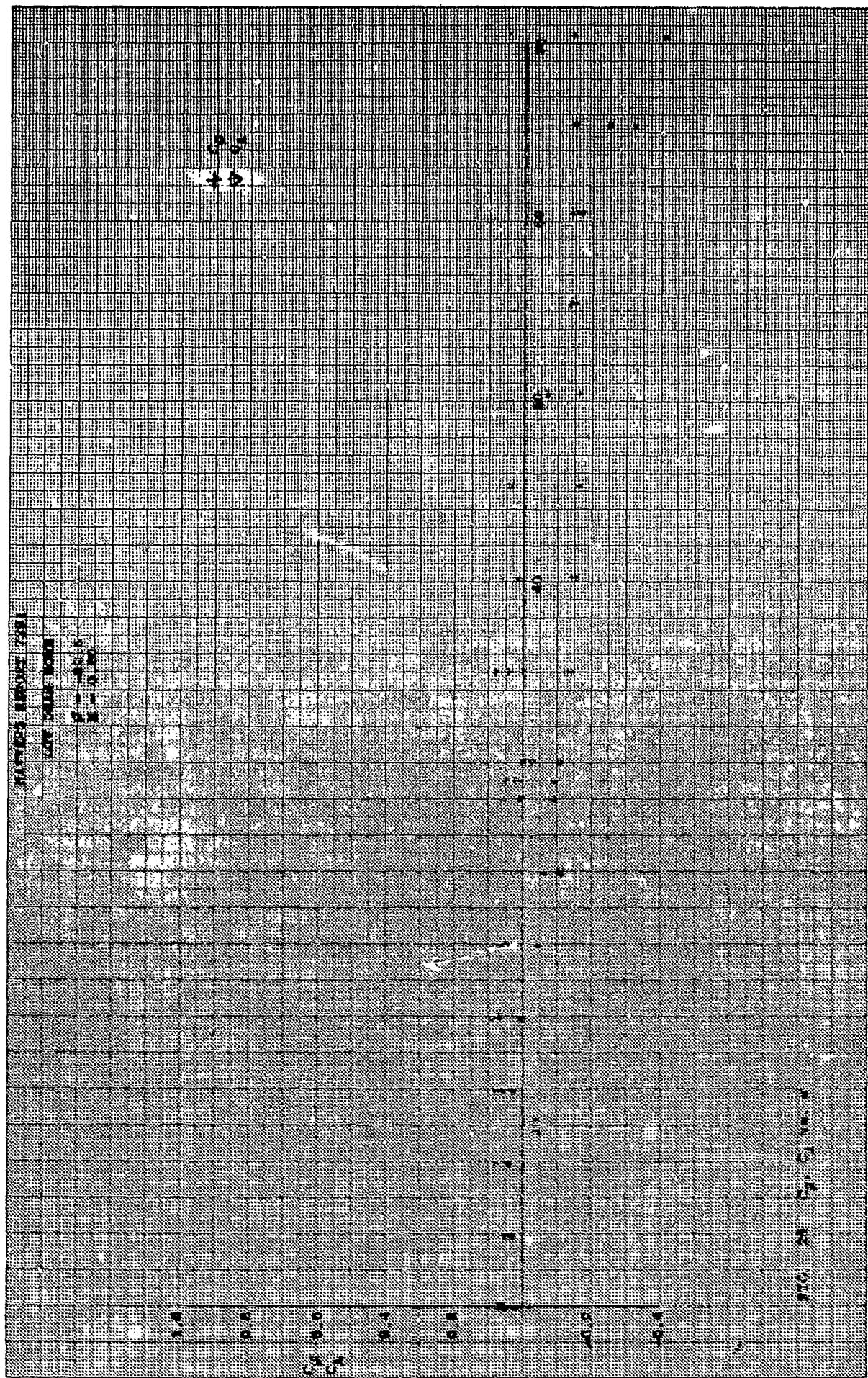
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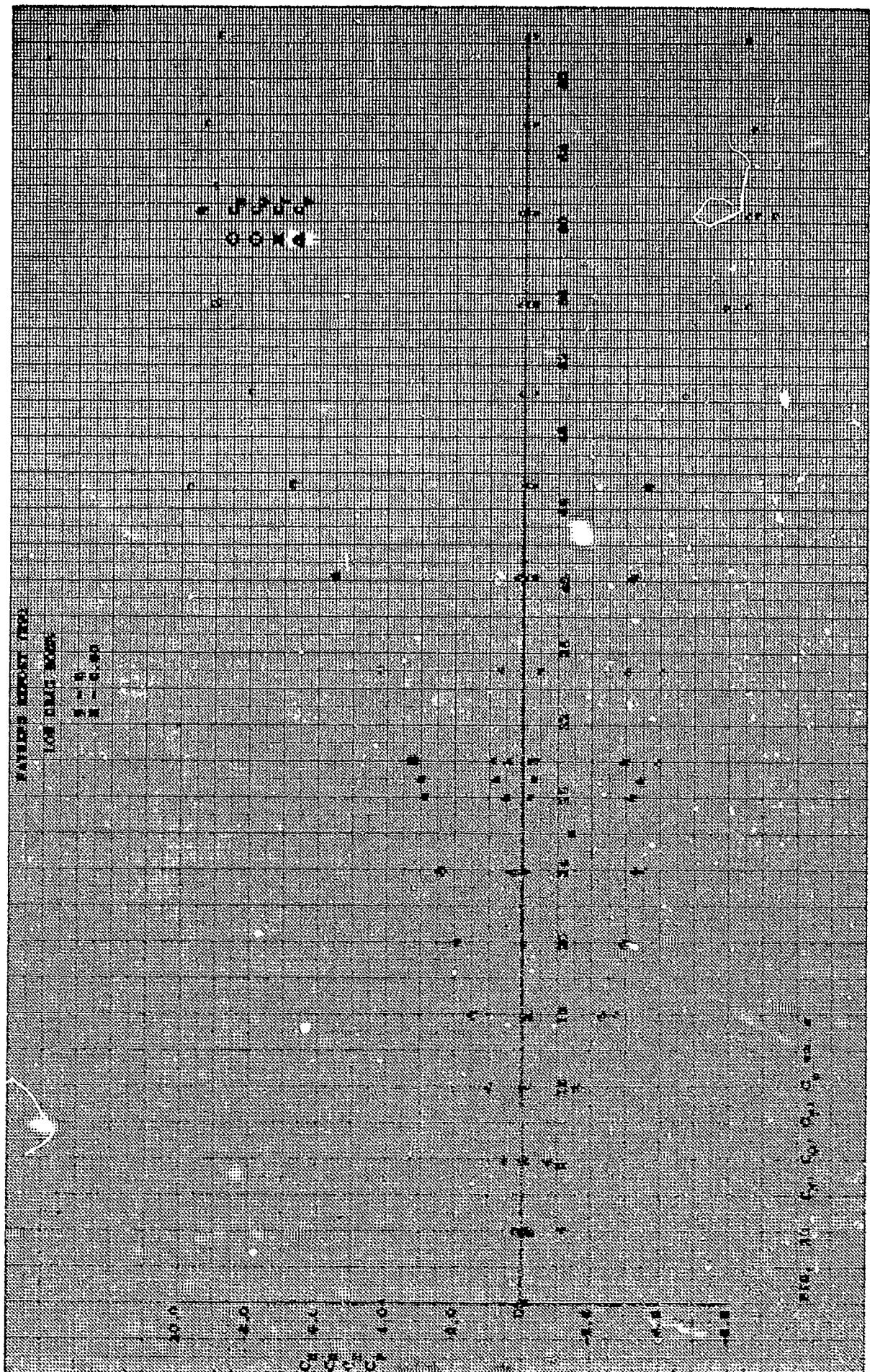
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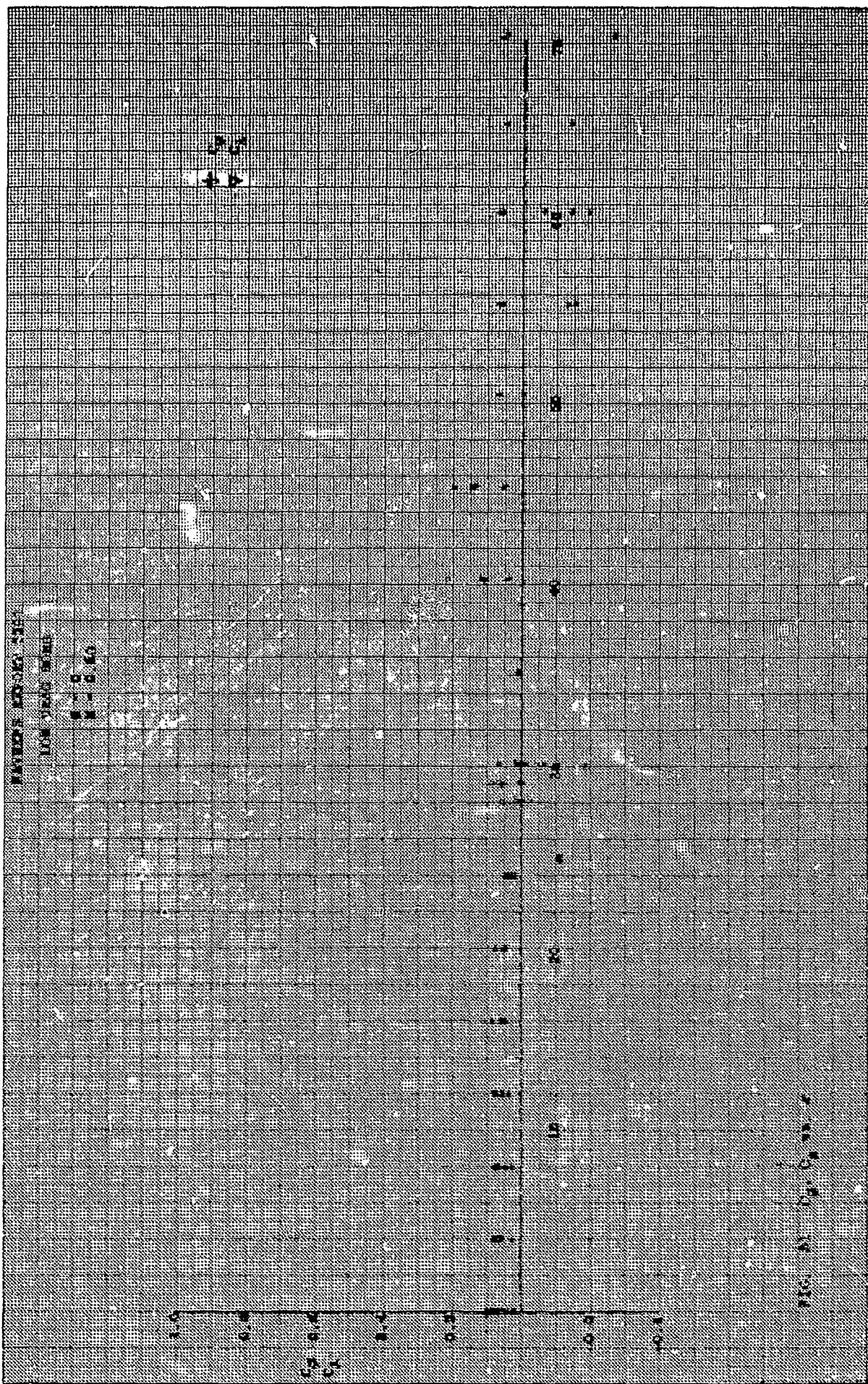
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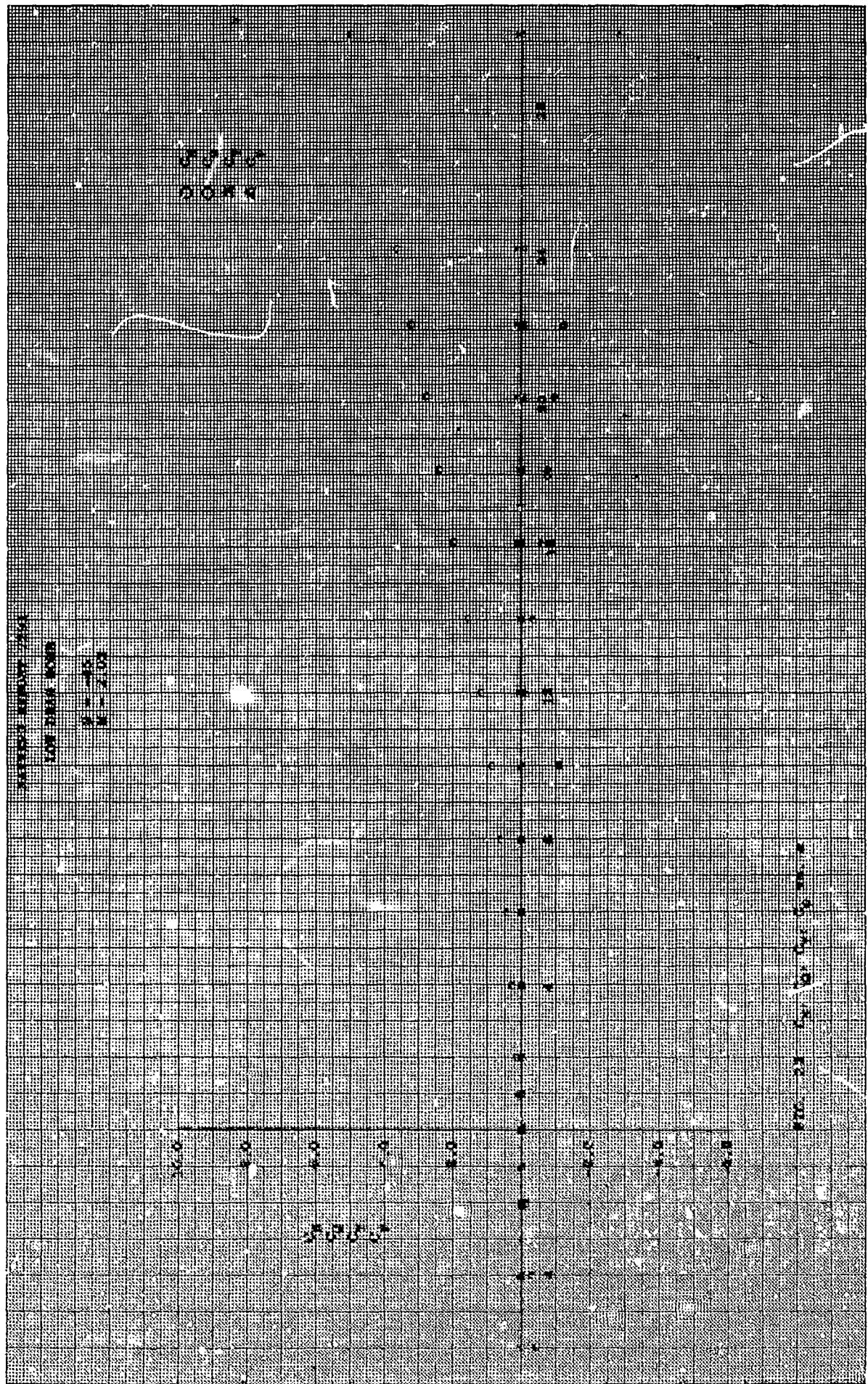
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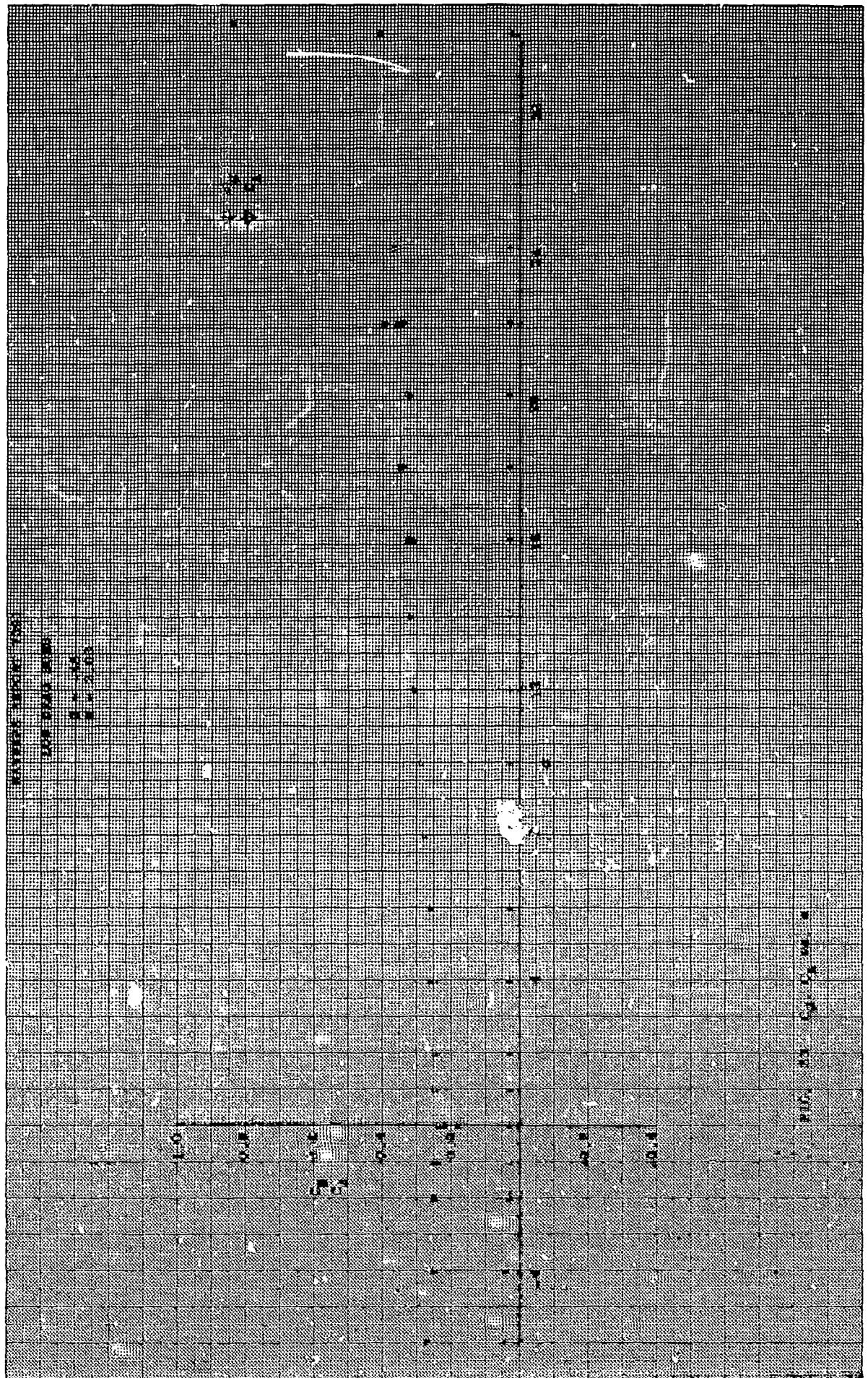




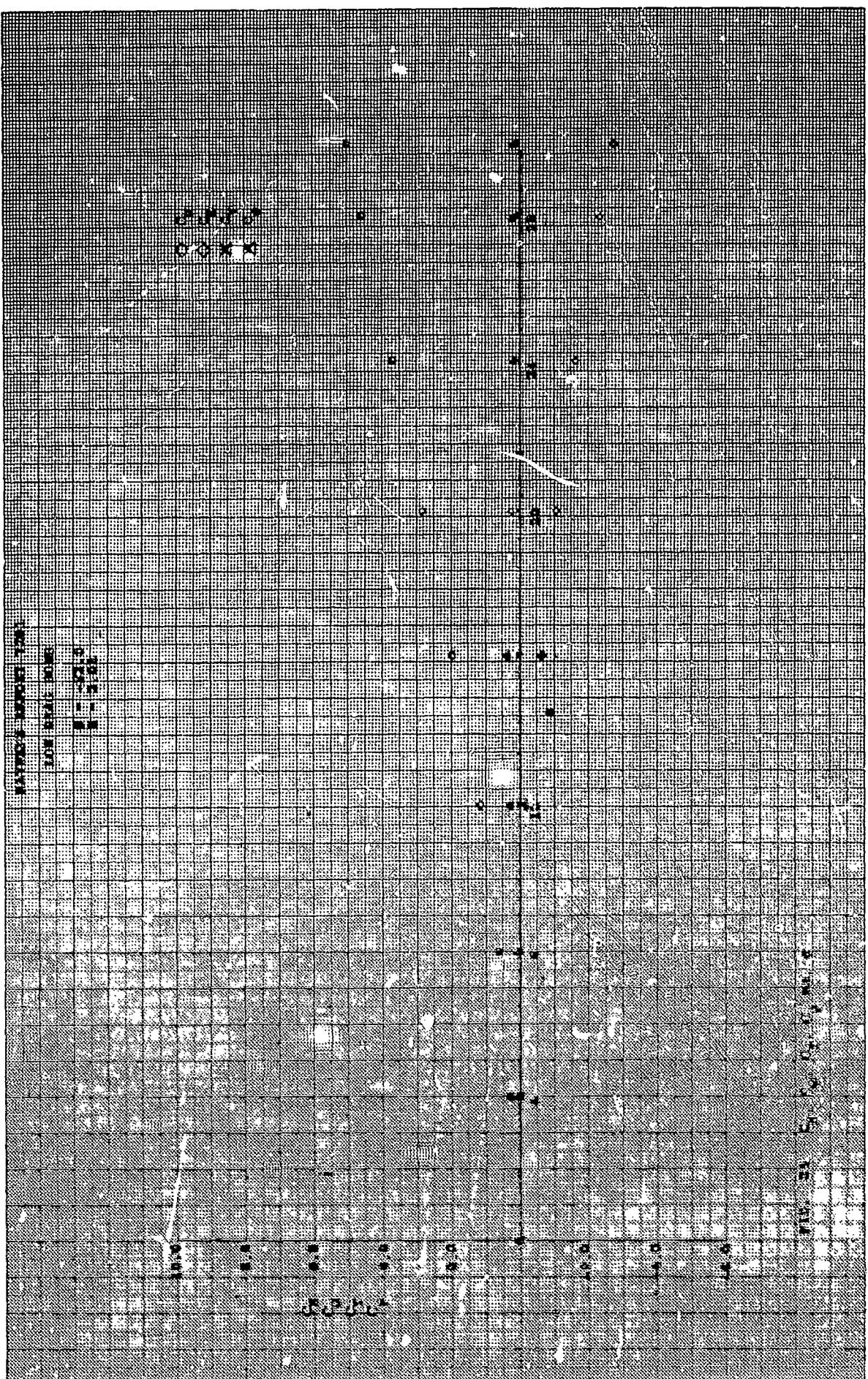








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K-2 10 10 10 10 10 10
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Marked Report Tag

LOW DRUG BOMB

G - 22.0

H - 2.03

b.0

b.0

C.0

C.1

0.1

0.2

0.2

0.4

PIC. 35 E₀ C₄ T₀

K-E 35 E₀ C₄ T₀

MAYOBS REPORT 7201

LOW DRAG BOOM

$\sigma = 0$

$M = 0.99$

○ ◇ × △

28

24

20

16

12

Fig. 3d Cor Cor Cor

HAWKER REPORT 2281

LOW DRAG BOMB

V = 0

S = 2.63

1.0

↑ C₃

↓ C₄

P.6.

P.7.

15

12

20

26

28

FIG. 37 C₃, C₄, v. 6

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